Helping Children Understand Science

Freeman
Dowling
Lacy
Tippett

Helping Children Understand Science

by

Kenneth Freeman
Thomas I. Dowling
Nan Lacy
James S. Tippett

Holt, Rinehart and Winston
New York

PRINTED IN THE UNITED STATES OF AMERICA

21919—0114

61D8

Preface

In the past decade educators have felt the need for greater use of science instruction in the elementary school to prepare children better for individual and group living. Some of the reasons elementary science is attaining greater prominence and importance in the elementary-school curriculum are the enthusiastic curiosity of children about science, the wealth of instructional material readily accessible in the community, the opportunity to plan new learning experiences with children and the opportunity to establish a basis for thought and action free from bias and prejudice.

Public schools have requested help in developing programs of science instruction in the elementary schools. Teacher-training institutions want help to improve the pre-service training of teachers. This book has been prepared to help teachers in training and on the job to be better teachers of science in the elementary school. It is not a book *about* science to teach but one which tells *how* to teach science. The principles of good teaching are presented in descriptions of desirable practices rather than as abstractions.

It is impossible for the authors to include specific reference to the many individuals who helped make this book a reality. Our deep sense of indebtedness to the teachers of the Lexington, Kentucky, Elementary Schools who contributed materials generously and to Miss Marilyn Neis who typed and proofread the manuscript is acknowledged with pleasure.

CONTENTS

Chapter 1

What Is Elementary Science?

Have you ever spoken a word to the children in a classroom and asked their immediate reaction upon hearing the word? It is an interesting experiment and shows the teacher the importance of developing meanings as well as word recognition. Let us suppose you had performed this experiment of reaction to hearing a word in your classroom, using the word "animal." The pupils may have given responses such as these: "My dog Blackie," "A bear," "Things that can run," "Things with feet," "Mammals," "They can all swim," "They make homes for themselves," "Covered with fur." Many other responses are probable, depending on the maturity of the children and their backgrounds of experience. It is apparent that some responses are correct, some partially correct but inadequate, and some incorrect. You will receive virtually as many different responses as there are pupils in the room. Each pupil constructs his own meaning from the experience he brings to the printed page. You have, for all practical purposes, said not one word, but many words, when you pronounce "animal."

"Science" means many different things to the teachers, supervisors, and students who use it. Each has constructed his meaning from his own background of experience. Obviously, the experience of elementary teachers in different communities is quite varied. Accompanying all of these meanings will probably be a tendency to think of elementary science in a somewhat narrow and limited way. This is not surprising, for the use of science in elementary schools has itself been limited. Failure of educators to

realize the many and varied possibilities in a program of elementary science has been a deterrent to its development. It seems appropriate, then, to consider the question: "What is elementary science?"

Science to some may mean "collections" of various things which become decorative curiosities rather than instructional materials. It is to others "technical stuff" beyond the comprehension of pupil and teacher. "Science readers" is descriptive of the meaning prevalent in many places. Say the word "science" to a group of elementary teachers. Ask for their first reactions. Inadequate experiences will probably produce inadequate meanings such as these quotations taken from responses of elementary teachers: "Nature study," "Object lesson," "Atomic energy," "Aquarium," "Animal cage," "A laboratory experience," "Part of the social studies," or "Rocks, birds, and shells."

The semantics of the word "science" is troublesome to others as well as to the teacher. The word has varied meanings among laymen. To some, it may mean effective procedures; to others, authority. Some conceive of it as truth; others as a school subject; some as a study hostile to religion. Most meanings attached to science by different people have an element of truth; some do not. Phillip G. Johnson points out several important contributions of science present in a composite of the varied meanings generally held. He lists ten major meanings of science:

> 1. Science does mean an immense and ever-growing amount of tested knowledge about our near and distant environment—its material, features, and forces. Every man himself is a proper object for study by scientists.
>
> 2. Science does mean a classification of ideas based on dependability in case the ideas are put to use.
>
> 3. Science does mean methods of thought and work that have demonstrated truly amazing effectiveness in arriving at repeatable results.
>
> 4. Science does mean an insatiable curiosity and a thirst for knowledge about the unknown.
>
> 5. Science does mean a cooperative undertaking—a keen job where ideas and results from the efforts of many persons are related to a common problem or goal.

6. Science does mean certain attitudes and standards which help persons to safeguard themselves from making errors in finding, selecting, and using evidence.

7. Science does mean a multitude of gadgets, devices, materials, and machines that help to relieve man of discomfort, drudgery, and constant attention to repetitious tasks.

8. Science does mean ways of improving on what happens naturally. It means removing or adding certain hindrances and adding or removing certain aids to changes.

9. Science does mean values that give direction and purpose to man's scientific endeavors.

10. Science does mean a humbleness of spirit in the face of the many unknowns that surround us, and it does mean an appreciation for the devoted work of other persons upon which we now can build.[1]

[1] Johnson, Phillip G., "Meaning of Science," *The Science Teacher*, November, 1950, pp. 161–163.

To some people, science means "Why?"

Wheelock College, Boston

Science Means Knowing One's Environment

When children are being helped to understand science, as the foregoing comprehensive meaning of the word "science" explains it, they are being helped to understand scientific attitudes such as inquiry and open-mindedness, the world of science, the scientific method, and man's efforts to use the facts and principles of science to improve himself and social living. The program of elementary science is a planned attempt to help children know and understand their environment and its impact upon them. The development of this understanding is to be achieved by guiding children so that they will recognize and solve their problems with procedures characterized by scientific attitudes, scientific method, and an alertness to social implications. Concomitant to this understanding will be a slow but steady building of the generalizations underlying the world of science.

Science Means Helping Children Solve Their Problems

The genesis of an elementary-science program is to be found in the eager question-asking of children. Hurley has stated this concisely and cogently: "One thing we find in common with these fine young people is that they all have problems of one kind or another, and that these problems relate directly to understanding themselves in relation to the environment in which they live and work. It is at this point science can help, for the method, the process of science teaching has as its real aim helping people find better ways of solving problems."[2]

The questions asked by children will not restrict the scope of the science program. They will be so numerous and varied that the guidance of the teacher must be used in selecting those most suitable for continued study. An extensive list of the questions frequently asked by children is presented in Chapter 4 as a measure of the child's readiness for science. The range of this questioning is well illustrated by four questions from that list: "Why do roots go down instead of up?" "Why do biscuits brown in the oven?" "How far away is the sky?" "Where do babies come from?"

[2] Hurley, Beatrice J., "Science Experiences for Nine to Twelve," *Childhood Education* 26, March, 1950, p. 300.

The observations of children are quite as important as their questions. They, in fact, generally imply a question or problem, for example, "The leaves in the gutter stink," "I am older, but Johnny's bigger'n me," "Magnets are sticky," "It's a trick."

Science Means Scientific Attitudes and Method

An elementary-science program based on children's questions nurtures and extends their interests and complements their enthusiasm. It is important that the teacher give the children opportunities to find their own answers, or there will be no possibility of developing scientific attitudes and scientific methods of procedure.

What is meant by scientific attitudes and scientific methods of procedure?

Curiosity and the spirit of inquiry are a part of what is known as scientific attitude. This aspect is frequently mentioned first because it is obviously prevalent among pre-school children who repeat, "What's that? What's that?" to the complete distraction of their elders. It is an indictment of our schools that, all too often, this eager question-asking is deadened by regimentation and replaced by an uncritical conformance to arbitrary adult

When, in answer to questions of "Why," experiments are planned and set up, development of scientific attitudes is taking place.

Bemidji State Teachers College, Bemidji, Minnesota

standards of behavior. Scientific attitude is becoming well established when one becomes a close observer and, through observation and experimentation, discovers facts for himself; develops a wider and deeper understanding of the world about him and a willingness to change his ideas as a result of new evidence; understands how the world has changed and is being changed by science; realizes the danger of scientific knowledge outstripping the world's sense of social responsibility; builds a wholesome appreciation of the world in which he lives, based on a knowledge of the universality of cause and effect and not on superstition, magic, prejudice, and fortune telling; rejects personification, mysticism, and gossip in making explanations; acquires a pleasant and profitable leisure-time activity; realizes that some natural phenomena have not been satisfactorily explained by scientists; strives for accuracy in work and thinking.

If children are ever to develop a scientific attitude, beginnings must be made in the nursery and kindergarten and built upon as the maturity of the child increases. A method of attacking problems must be built. Children should be taught to recognize and state problems clearly; formulate a working hypothesis; weigh the evidence; look at the problems from every side before expressing an opinion; distinguish between fact and fancy; recognize whether a given fact has any bearing on the problem; withhold judgment until there is enough evidence to justify drawing conclusions; demand reliable sources of information and weigh conflicting authorities; change conclusions when additional reliable information warrants it; take whatever action is indicated as necessary by the conclusions.

The following statement by teachers of the philosophy of education is an inclusive and clear summary of the meaning of the scientific method: "The method of science, extracted from any particular content, is a way of approaching problems that may be described as follows. It is based upon empirical observation and analysis; it projects hypotheses; it tests hypotheses and consequences by prediction and verification; it tests, also by accounting for facts that are hit upon in the process of testing itself; it describes openly and publicly the procedures used; it seeks for further refinement and development of the process

itself; and it is ready, with this ground of testing established, to act as the hypothesis seems to warrant, yet it is equally ready to re-examine any hypothesis so established as new facts, conditions, situations, or ideas place a demand that this be done."[3]

The development of scientific attitudes and of the scientific method is not limited to contacts with natural environment. All avenues of learning, all subjects of study, all experiences and activities lend themselves to the practice of it. It is, however, through science that the scientific attitude and method is most surely and accurately developed. Data can be more easily and extensively gathered, more readily manipulated and controlled, and more completely checked than in other areas of the school curriculum. The natural environment is, in general, more provocative of questions and more stimulating to the child's curiosity than any other area.

Science Means the Use of Science to Improve Living

The relationship of science instruction to the school's attempt to help every individual lead a worthwhile life is admirably stated by Brunson and Dowling: "A responsibility of the school is to help every individual to lead a worthwhile life. Those situations which can be better met by an understanding of the basic concepts of science become forts of science instruction. Physical and mental health, which are affected by sleep, rest, fatigue, diet, exercise, posture, and drugs can be better assured for the pupil. Self-assurance, which comes from a sense of achievement and an understanding of normal variability, is necessary to the best adjustment and can be built by the study of science. Through an understanding of organic and inorganic changes, the pupil gains appreciations which help him to see himself in his proper place with relation to the world about him. By constant practice in recognizing problems, seeking evidence to be weighed, and arriving at conclusions, the scientific method becomes a basis for action with the pupil. Science can help present

[3] Armagido, Harry, "The Thought of Oliver Wendell Holmes, Jr., and the Pragmatic Philosophy of Education." Unpublished doctor's dissertation, Ohio State University, 1950, page 110. A statement worked out with H. Gordon Hullfish. Used by permission of H. Armagido.

certain fundamental principles which should be understood through taking part in and preparing for homemaking. Any adjustment to life which overlooks an appreciation for beauty found in the complexity and orderliness of the organic and inorganic world cannot lead to the development of a well-rounded personality."[4]

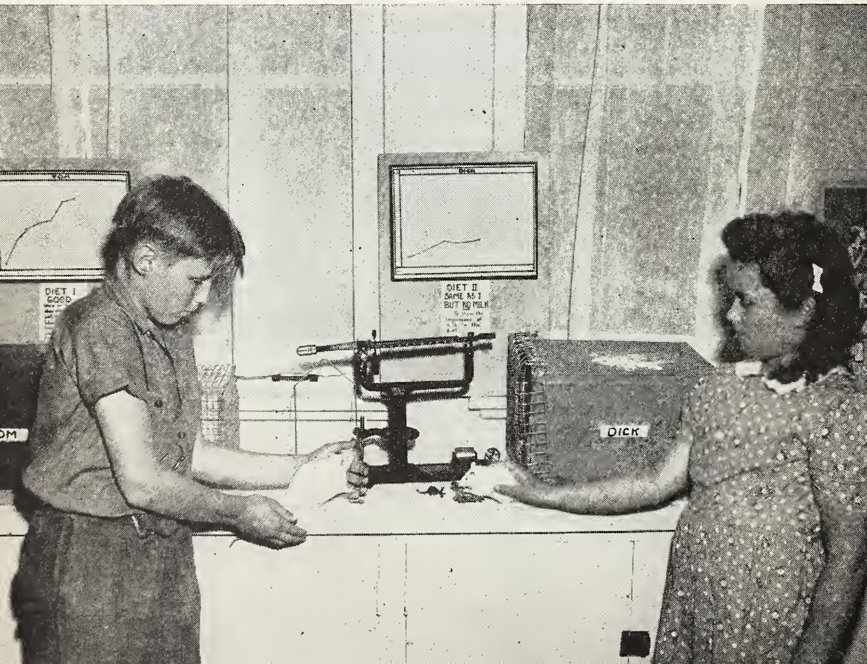
Science Means "Content"

The content of a program of science designed to meet the questions of elementary-school children will need to touch upon aspects of the world of science such as the following: 1. weather and seasons; 2. plants and animals; 3. health and food; 4. sources of heat and light; 5. magnetism and electricity; 6. machines and energy; 7. chemical elements and compounds; 8. the earth and how it came to be; 9. sound and light; 10. interdependence in nature; 11. inventors and inventions.

[4] State of South Carolina, Department of Education, *Suggestions for the Teaching of Science in the Twelve-Year School Program*, 1946.

Watching the effects of diet makes science content concrete.

San Diego County Schools, Calif.



Planned courses in science will be discussed and analyzed in Chapter 7. Scientific concepts to be developed by a study of the above topics and others will be presented in detail.

Summary

The meaning of "science," if rightly conceived, is not narrow or limited. No aspect of the meaning should be neglected in planning the program of science for the elementary or any school, or in carrying out the program in classrooms. Attitude, information, method and application to individual and social living all must be included in a program adequate to measure up to the requirements set by the comprehensive meaning which has been given.

Increase Your Understanding

1. Why should the following descriptions of science be unacceptable to a successful teacher in the elementary school? A. Science readers. B. Nature study. C. Collections. D. Bird study.

2. Show that you understand application of the scientific method by describing its use in specific instances by the following scientists: Pasteur, Carver, Edison, Fleming, or others. Describe an application of this method which you have made recently.

3. Compare other statements of the major meanings of science with those of Phillip G. Johnson given in this chapter. Is there substantial agreement?

4. "The genesis of an elementary science program is to be found in the eager question-asking of children." Keep a record of the questions asked by a group of six-year-olds during a week. Would such a record be the answer to, "What science experiences should these children have?"

5. Do you consider action based on solution of a problem as a necessary part of scientific method or a scientific attitude? Why?

6. Here is a report of an alleged use of the scientific method. How is the method perverted? How can one avoid these misapplications?

> The superstition I have chosen is: If baby chicks are hatched on the full moon, the egg productions of these pullets will be greater and the mortality less than if the same chicks had been hatched on the new of the moon. My husband and my father, both being successful and experienced poultrymen, have tested this superstition over a period of five years with the following procedure. Each of them gets his replacement flock of approximately one thousand pullets from the same flock. Due to the smallness of the laying flock, it is necessary that two weeks elapse between each hatch. It so happened these five years that one of them would get his baby chicks on the new of the moon, the other getting

them on the full moon. The chicks were being fed the same feed, brooded identically in every respect, ranged on the same type of range, housed in almost identical laying houses, and cared for with the same attention. Over the period of time, the men found that the flock hatched, regardless of which flock—whether my husband's or father's—on the full moon, have profound advantages on egg production, mortality rate, and a slight difference in size. Therefore, this scientific test has proved to both my husband and my father that, beyond a reasonable doubt, the moon does determine this advantage, thus bearing out the superstition.

7. Describe another application of the scientific method that is faulty. Point out its faults.

8. Collect from ten teachers their statement of meaning for science when it is used in the phrase, "the program of science in the elementary school."

Additional Readings

Association for Childhood Education, *This Is Science*, Washington, D. C., The Association, 1945.

Blough, Glenn O. and Huggett, Albert J., *Elementary-School Science and How to Teach It*, The Dryden Press, 1951. pp. 5–8.

Caswell, Hollis L. and Foshay, Wellesley A., *Education in the Elementary School*, American Book Co., New York, 1950. pp. 138–146.

Commission on Secondary School Curriculum of Progressive Education Association, *Science In General Education*, Appleton-Century-Crofts, Inc., New York, 1938. pp. 309–313.

Craig, Gerald S., *Science For The Elementary-School Teacher*, Ginn and Co., New York, 1947. pp. 3–20.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 5–19.

Shane, Harold G. and McSwain, E. T., *Evaluation and the Elementary Curriculum*, Henry Holt and Co., 1951. pp. 232–263.

The National Elementary Principal, Thirty-Second Yearbook, *Science for Today's Children*, National Education Association, Washington, 1953. pp. 1–22.

Chapter 2

The Teacher and Elementary Science

THE teacher, more than any other person on the school staff, determines the quality of the educative experiences provided the children. Science instruction is no exception to this general principle. It is natural, then, that the well-known hesitancy of some teachers to utilize science experiences in guiding child development is a matter for concern. This concern can be alleviated, in part, not only by helping these teachers understand what is meant by elementary science but also by examining some of the fears that teachers have and by showing how such fears can be eradicated or reduced.

The importance of this first step of eliminating misunderstanding is illustrated by many instances cited in the preceding chapter and in the following report of teachers, "Science means something highly technical that I know next to nothing about. Besides, I can think of no way in which this complicated and difficult thing I struggled with in college can give opportunity for enthusiastic learning activities for children.

"Probably it was the high school and college teachers who first frightened me about science. I survived the 'lending library of facts and ideas to be taken out one week and returned the next' era and became a good little conformer. I memorized with the best of them, but I developed a dislike for science, and now that I have to teach it, I am afraid of it."[1]

[1] Pike, Louisa, "The Teachers Speak To Their Principals", *The National Elementary Principal*, February 1950, p. 9–11.

Misunderstanding of the meaning of "science" can be eliminated and, although the fear of teaching science is quite common among elementary teachers, it is not an insurmountable obstacle. It is interesting to note that these same teachers are not afraid of teaching reading or arithmetic, subjects to which children may bring less natural readiness than they have for science. Quite as common as the prevalence of this fear of teaching science is the vanishing of it with some experience in elementary-science work. This is borne out by the experiences of teachers in Lexington, Kentucky. Teachers there, with no specific training in the teaching of science, worked with groups of average children for six weeks one summer. Typically, these teachers wondered, as most elementary teachers have wondered during the past decade, if they "knew enough science to teach it." They found that it was not necessary to be trained scientists or to know all the answers. It was, perhaps, a more wholesome attitude for the teacher and children to study and learn together. These teachers learned other things from this experience. But, before the answers they found are considered, a look at the needs as expressed by teachers and an exploration of ways of meeting these needs will be rewarding.

Workshops for teachers give them confidence to undertake a program of elementary science.

Stockton Unified School District

Teachers' Reasons for Not Teaching Science

There are extensive lists of reasons why science is not taught in the elementary schools. Most of these are compilations of statements by teachers. No doubt some of these reasons seem to some teachers invalid; in fact, merely excuses. Others seem defensible in most situations. Reasons involving attitudes of communities and administrators toward curriculum are usually not stated publicly by teachers. The following list is adapted from one accumulated and compiled by teachers in education classes over a ten-year period. It is quite comprehensive, but still growing.

1. Teachers have not been trained to teach science and do not know the subject.
2. The course of study is not adapted to the grade level of elementary schools.
3. Teachers felt the need for elaborate material.
    a. Teachers are not informed as to sources of materials to be used.
    b. Teachers do not make use of available materials.
4. Teachers do not receive adequate encouragement from administrators.
5. Teachers feel that teaching science is not necessary, since the students are not to be tested in science in any testing program.
6. Teachers are often afraid of the reaction of parents and some religious groups if science is truly presented. (Tradition and prejudice prevent teaching the proved facts of science.)
7. Some schools have science clubs and feel that this, in itself, is enough science.
8. Elementary teachers feel that science should be left for the high school and are often encouraged by high-school teachers in their feeling.
9. Teachers refuse to cooperate in a science program by not lending equipment and use of laboratories.
10. Some schools refuse to allot time for science.
11. Teachers lack enthusiasm for adopting another hard job into an already full schedule of work.

12. Since some courses of study do not stress or even include any outline for teaching science, teachers feel that it should not be taught.

13. Teachers do not teach science for fear that the slow-learning pupils will not have enough time for drill in reading, writing, and arithmetic skills.

14. Since classes are frequently overcrowded, the teacher feels that no space is available for scientific equipment and that, therefore, pupils are best kept in their seats.

15. The teacher does not know that there are people in the school and community who can help her with the facts she needs to know.

16. Teachers have no surveys of the communities to show what possibilities for science teaching exist in their environment, as for example

a. Animals, wild and domesticated
b. Plants, crops, soil, seasons, climate, weather
c. Farm, community, and household machinery
d. Dairying, gardening, construction, occupations of all kinds.

Pre-service and In-service Training Needed

Specialists in the field of science education who have studied this problem of helping elementary teachers to teach science emphasize certain inadequacies in the pre-service and in-service training programs of teachers. They point out that many teachers find it difficult to recognize the science problems and interests expressed in their groups. This is, in part, due to the fact that very few colleges have made it possible for a student to develop a functional background in science understandings. Where science requirements exist in pre-service education programs, they are usually stated in semester hours of any one of a number of highly-specialized science courses.

Most prospective teachers or experienced teachers have had some contact with the field of child growth and development. They have studied it in college or in workshop groups while on the job. There is, however, a great tendency to fail to present the knowledge we have of how children grow and develop in a

functional manner. Very infrequently are the implications of our knowledge of child growth pointed out to teachers for the use of specific instructional aids in specific situations. Teachers need help in selecting appropriate equipment and suitable experiments for children of the various age levels.

One of the most inhibiting factors in this whole problem is the failure of educators to meet it head on. Administrators and supervisors have not given teachers the encouragement and stimulation to assume responsibility for providing real science activity. Cooperative planning and immediate attack would result in the dissolution of most of these problems in a very short time.

If the teaching of science is to be effective, the facts and laws of science must be put to use by pupils, or at least observed in operation. That means activity, and many teachers prefer not to allow much of it in their classrooms. They have learned that the science teacher must think of the purpose of his work as changes to be brought about in the thinking and behavior of the pupil rather than as teaching facts. It is obvious then that the importance of content lies in its use as an implement rather than an aim. That statement implies that science is not to be thought of as an end in itself, but as a means to an end. Alas, too often are other subjects, such as reading, writing, and arithmetic, taught as ends in themselves, and teachers find it difficult to get away from that kind of procedure.

What Help Do Teachers Ask For

In view of the reasons expressed by teachers for not teaching science in the elementary schools, it seems reasonable to expect that they would request opportunities to observe other teachers who are at ease with children in the attempt to solve problems using science materials; to examine and have access to a wide variety of reference materials, books, filmstrips, films, simple equipment; to manipulate simple materials for the learn-by-doing process we expect them to use with children; to plan ways for organizing field trips and excursions; to utilize the human resources of the community wisely; and to have a time and place to discuss common problems, ask questions, and share information.

A group of teachers in a study-workshop course in the teaching of science in the elementary school were asked what help they wanted in developing their programs in science. They said that they wanted help in these aspects of the program:

1. To know where to find answers to questions
2. To learn some facts and generalizations of science
3. To get a list of library materials for science
4. To be given a sampling of experiments that may be performed by elementary-school pupils
5. To be given a list of inexpensive equipment
6. To know what movies and other visual aids are suitable for different topics in science
7. To list the generalizations that should be arrived at by the end of the sixth year of an elementary school
8. To know how to simplify the college science which teachers know so that it will suit the age level of children in their classes
9. To know the trends in teaching science
10. To see courses of study that have developed in various communities
11. To understand the scientific attitude
12. To know physics.

Information in Science Desired by Teachers

Another group similar to the one above made a list of questions which the members of the group wanted to have answered during the progress of the course. These questions have been grouped under appropriate headings. They are questions that children also might ask. Teachers could easily find answers to almost all of them by referring to the sections on information in areas of science which are given in Gerald S. Craig's *Science for the Elementary-School Teacher* or Glenn O. Blough and Albert J. Huggett's *Elementary-School Science and How to Teach It.*

Weather

Where does dew come from? How are clouds formed? What makes rain? What is the difference in formation of sleet and snow? Is there a gradual change in our seasons taking place?

Why? What causes the weather to change? How are glaciers formed? Why do we have the four seasons? Why do they vary in intensity? What makes snow and hail? How high are clouds able to exist? What makes hail in hot summer? Why does it rain more in some towns than in other near-by towns? Why are mountains cold? What are highs and lows? What causes a colored ring around the moon? What causes fog? What instruments are used in forecasting? What is the work of the weather bureau like? What causes climatic changes? What makes frost? What causes the sun to shine when it is raining? Why is the air cooler near clouds even though it is nearer the sun?

Electricity and Magnetism

Why do people put lightning rods on their houses? How does radar work? Is fluorescent lighting better than ordinary lighting? Is it true that lightning never strikes twice in the same place?

Actual handling of dry cells, coils and magnets will answer many questions concerning them.

Louisville Public Schools, Louisville, Ky.

How can magnets lift objects? What causes lightning and thunder? Why does rubbing cat's fur produce electricity? What is a short circuit? What causes one? What are the Northern Lights? What makes electric lights burn when you push a button? Does voltage affect the light output of a bulb? How is an electromagnet made? What causes steel to become magnetized? Why is frequency modulation free of static? Why can birds sit on an electric wire and not be killed? What is electricity?

Animals

Why do some animals have fur and others have feathers? Why do people have different colors of hair and eyes? What is the difference between a toad and a frog? Why do some animals reproduce at a more rapid rate than others? Why do bears hibernate? Why do beavers build dams? How can some animals go through winter without food and water? Why do some fish live in salt water? Would a salt-water fish live in fresh water with salt in it? Why do men get bald-headed and women don't? How do birds fly? How do birds know when to fly south? Why is the cardinal's mate a different color? How does Nature produce changes in color of the same bright-colored bird? Why don't male birds sit on eggs during hatching? Why do some birds migrate? Do they return to original homes to nest? Why do owls see better at night? Do insects have any intelligence? Are ants any smarter than other insects? How does a caterpillar change into a moth? Why are bugs so strongly attracted to light? Why is the life span of a moth so short? How do the cocoon of the moth and the chrysalis of the butterfly differ? Do all, some, or any spiders build a new web every day? How does a spider anchor its web? What causes spider-web thread to be so strong compared with its diameter? Why does an opossum hang by its tail? How are fish able to breathe under water? What is the difference between a horse and mule?

Plants

Why don't evergreen trees lose their leaves? Does grass contain vitamins? Would it make good food for human beings? Why do some plants, such as mushrooms, moss, puff balls, and

toadstools, have neither seeds nor flowers? What causes fungi and algae? Where do they come from? How can we distinguish between mushrooms and toadstools—that is, the edible form? Why is moisture necessary to sprout a seed? What causes leaves to fall in autumn? When do pines shed their needles? Why do white and red oaks not mix? Why do scrub oaks follow long-leaf pines? What causes plants to be green and yellow? How can we tell how old trees are? Is rain better for plants than water from a hose? Why do some plants require a moist environment?

Water

Does the ocean actually lose any water? Is there a water table below the entire surface of the earth, or only here and there? What is an oasis? Is there a possibility that the present ratio between the water and land will ever change? Why is water harder or softer in some localities than in others? Are the Atlantic and Pacific Oceans at the same level?

Materials

What are blackboards made of? Why does iron rust? Is fish cooked without salt less nutritious than with salt? Why is clay more suitable for making pottery? Can man predict whether the supply of coal will become exhausted any time soon? What makes "invisible" ink invisible? How is plastic produced? How is milk homogenized? How is the atom bomb made? What causes cakes to fall? What causes cotton clothing to shrink?

Energy and Force

What makes water come out when you turn the spigot? What makes an airplane fly? Why does it take off? Why can ships stay on water? How is steam used to operate a locomotive? How is gasoline used in a combustion engine? What happens when an auto driver places his foot on the starter?

Solar System

How do comets and planets differ? Why are there different constellations in the sky at different times of the year? Why do stars vary in brightness from time to time? How are tides caused

by the moon? What is the difference between a meteor and a meteorite? What is the greatest distance from the earth that the law of gravity applies? Is there any possibility of animal life existing on any of the other planets or the moon? Why do we have eclipses and tides? What makes the earth rotate? What is the nearest heavenly body to the earth? Why is the sky blue? How long has the moon been a dead planet? Do stars ever burn themselves out? Is the sun closer to us now than during the Ice Age? Is its heat becoming more intense? What makes the moon change shape? Why don't we hear of half moons when we have quarter moons? What causes a star to fall? Why do stars twinkle? Does the moon affect crops?

Sound

How does the phonograph work? Why does water carry sound faster than air? Do sound waves ever exhaust themselves, or are they forever in motion? What makes the radio play when you turn it on? What makes sound travel? Why can we hear better across a lake than across land?

Light

How does a camera work? Why is a cloud dark before a storm? Why is a rainbow an arc? What makes the color in flowers? What causes a rainbow? Why do wheels in moving pictures seem to go backwards? What makes daylight even though the sun isn't shining? What makes a mirage? Why does a highway sometimes look wet when it hasn't rained? How are pictures taken, developed, and printed? How does television operate? What makes lights burn? Can cats see in the dark? What causes certain vivid colors to waver before the eyes?

Earth

Is there any record of earthquakes having occurred in this area? What causes the weathering of rock? What causes the different kinds of soil—loam, gravel, clay and sand? How long does it take a river to cut a new bed? What causes volcanic eruptions? What causes an earthquake? Why are we not conscious of the motions of the earth? Why is delta land rich? Were

sand areas caused by a receding of the ocean? What causes soil erosion? Why are earthquakes more frequent in some places than in others? What makes rocks?

Heat

What causes the wind to blow? What causes a match to burn? What causes monsoons? What happens in spontaneous combustion? Why is the sun invested with so much heat? How does it acquire it? What causes tornadoes? Why do auto tires gain air pressure in hot weather?

Miscellaneous

Which is the most important to man, heredity or environment? What authentic history do we have on the theory of evolution? How can one tell that dinosaurs lived fifty million years ago? Are there other worlds? Why don't they fall on us? How can doctors predict the mentality of a child at birth? Do you get wetter in going a certain distance in the rain if you walk or if you run? What reasons are there for freaks in nature? How can virus infection be explained? Is it possible for a person to die of old age?

These questions are indicative of a basic inadequacy and the desire to overcome it. These questions and others like them must not go unanswered. The means for giving this needed help to teachers is the next consideration.

It has already been suggested that answers to the questions may be found in books containing information about general science. All schools should have one or more copies of such books of information always accessible to teachers. Many teachers should be encouraged to take additional courses in general science, now frequently offered by colleges. Other ways to provide help for teachers who are hesitant about undertaking instruction in science in the elementary school are now being used most successfully. Descriptions of some of them follow.

How Can Teachers Be Helped?

The more competent elementary teachers have long ago learned the best way to get help is to help one's self. There are

many things a teacher can do to help herself directly and also to facilitate getting help from others.

What are some general principles governing our actions in such circumstances? First, we must be able to define our problem clearly, specifically answering the question: What kind of help do I need? Second, we must decide which of our problems can be solved personally and which require the assistance of other people. We may find our initial classification will need slight revision as we proceed. Flexibility is a good watchword. Third, we must be willing to be a learner. This is a matter of attitude. It is difficult to help ourselves or have others help us unless we have the humbleness, inquisitiveness, industry, critical judgment, and other desirable attributes of a good learner. Fourth, we must vigorously and enthusiastically attack the problems, seeking help from all available sources. The pupils, fellow teachers, principals, supervisors, community people may all be sources of help. Fifth, we must share our findings with our associates, for this encourages a reciprocal arrangement which improves the effectiveness and morale of a teaching staff.

Teachers may reasonably expect to have more definite help than that provided by the above list of principles. What are some specific things that we may do to help ourselves improve in the teaching of elementary science? The following list is not new nor all-inclusive, but any teacher who has done all of the things indicated will be well on her way to being a competent teacher of science in the elementary school.

1. Read the literature and research in the field of elementary-science teaching. There is no substitute for a scholarly approach. One can always profit immensely from reviewing the experiences of others who have worked in this field for years. Magazines, such as *Science Education*, *The Science Teacher*, *School Science and Mathematics*, are good sources for this information.

2. If the science background is weak, one should, as a beginning, read some good high school text such as *Basic Science*, by Barnard and Edwards, published by the Macmillan Company. There are many fine books available for such use.

3. Use a good elementary-science textbook. Such publications serve well as a guide for the teacher. One must bear in

mind that any textbook must be adapted and supplemented in view of local, individual, and group problems.

4. Teachers manuals accompanying the textbooks will give a wealth of helpful suggestions to get you started. Many teachers fail to capitalize on this material.

5. Science can best be learned by doing. Work with children in performing the experiments. Learn with the children.

6. Evaluate your efforts. Keep notes on successful efforts. Use them again with the next class. Also note helpful suggestions made by the pupils.

7. Participate in in-service workshops and seminars provided by the school system.

8. Use all sources of instructional materials provided by the school, such as library, visual aids, museum. Be alert to out-of-school sources.

9. Survey your community for resources for science teaching. Most of the things that one needs for teaching science in the elementary school are all about and easily obtained.

10. Use your knowledge of children's growth patterns for a wise selection of suitable learning experiences.

11. Realize that a good beginning program of science does not try to cover the entire field. The quality of instruction is of greater importance than the amount of science covered.

It is regrettable that over the years teachers have had to rely so heavily on their own resourcefulness and initiative in improving instruction in the elementary school, and particularly in the field of elementary science. There are many things that the elementary-science consultant, the elementary principal, and other school officials may do to help the teacher. The title of the person helping the teacher is not important, and although these titles may vary greatly, the way in which the person functions should always be as a resource person or as a co-teacher. Efforts made in a setting of such friendly relationship will result in much greater success. A high-school teacher of science or an elementary teacher who has specialized in science may serve as the consultant.

Science consultants expect to help teachers in many ways. They stand ready to plan ways for teachers and pupils to include

science in classroom experiences. Creating an interest or developing an existing one may be necessary. It is the job of the consultant to suggest ways that instructional materials and equipment may improve instruction. Unexpected problems that arise may be referred to the consultant. Teachers may expect the consultant to assist in conducting workshops and demonstrations, which increase the teacher's knowledge of science and how to teach it. Consultants are generally willing to teach small groups or individuals, to participate in the planning of a unit of work, to provide science data, to give suggestions to improve teaching, to locate materials and equipment and to help in many other ways.

In communities where consultants only "rate the teachers" there is a skepticism about consultative services. The following brief illustrations show effective teamwork of teachers and consultants. Note that among the consultants are a high-school teacher and a county agent.

A teacher in a western community became disturbed by the few educative experiences that grew out of "Fire Prevention Week" in her classroom. She talked to the local high-school science teacher about possibilities for science instruction related to fire and fire prevention. Many simple experiments with air and fire suggested by the high-school science teacher were performed by the pupils. They learned how to start a fire with friction and that fire needs air. They showed how a fire extinguisher works by putting out a flame with a homemade fire extinguisher using the carbon dioxide formed by vinegar and baking soda.

The lack of interest shown by children in conservation troubled a teacher who taught in an area where natural resources were being rapidly depleted. The teacher asked the county agent for help. He volunteered to conduct a field trip for the class to show them what needed to be done and why it was needed. He also provided printed materials and visual aids. The pupils and teacher planned a school garden and school grounds beautification project to apply and test what they had learned. Many experiments were conducted to learn the effect of wind and running water on soil.

In another school a fourth-grade child, new to the school, had difficulty in adjusting to the group. He was ignored by the other pupils. One day the science consultant came, at the request of the teacher and pupils, to help them plan an aquarium. In the early part of the discussion the consultant learned that the poorly adjusted newcomer had done a great deal with an aquarium in his home. The newcomer was asked to tell about his aquarium, and the consultant suggested to the teacher that she had found the chairman of the group to fill the aquarium. Teamwork had helped the boy find his place.

Schools in a common geographic area with limited individual resources can quite profitably sponsor jointly a week-end workshop designed to improve instruction. The cooperation of the group makes possible a much better program for all.

These workshops should be based on problems in which teachers are interested and need help. They should include recreational activities, exhibits of various types, resource persons with special training, visual aids and field trips into the community. The schools will find that the State Teachers College or University in the area will be glad to help sponsor the workshop.

The following program suggests a plan for the workshop that involves no loss of school time. Activities of this type are important and may be scheduled during school time.

Elementary Science Workshop

Friday

7:00 p.m.	Dinner
8:00 p.m.	Opening lecture by consultant from cooperating college or university
8:30 p.m.	Announcements for plans for following day

Saturday

8:00 a.m.	Breakfast
9:00 a.m.	Field trip conducted by a "master" teacher showing things to see and to collect followed by a brief talk about science information and principles that may be taught in this way. Conclude with a question period.
10:30 a.m.	Film and other visual aids. Preview a film aided by a teacher trained in visual aids or a consultant. Plan how the visual aids are to be used with children.

12:00 noon	Luncheon—Group singing and fellowship
2:00 p.m.	Volunteer participants form groups of four to six. They are given small pieces of paper on which simple experiments are described. In one hour they are to obtain materials and perform experiments before total group. Then tell what science knowledge and principles are illustrated. Also tell for which age level the experience is suited.
4:00 p.m.	Visit to classrooms equipped for good science instruction. Teachers are present to answer questions and demonstrate apparatus.
6:00 p.m.	Outdoor wiener roast. Observation of heavens.
8:00 p.m.	Rest and recreation.

Sunday

9:00 a.m.	Breakfast
10:00 a.m.	Small group discussions designed to identify current problems of teaching elementary science.
11:00 a.m.	Church
1:00 p.m.	Luncheon
3:00 p.m.	Inspirational address by consultant on importance of science in solution of world problems.

The culmination of a teachers week-end seminar or workshop in science may be an exhibit of materials which the teachers may use or reproduce in their own classrooms.

Murray State College Training School, Murray, Ky.

The foregoing program is merely suggestive and is subject to much improvement. It does show how teachers may have a profitable and pleasant workshop experience. Encouragement and stimulation for science teaching will almost certainly result.

Science fairs are effective means for in-service training of teachers. The work in science from many classrooms may be taken into a large room. Collections, notebooks, charts, experiments, and books of science could be put in the science fair. Everyone could learn something and be made more enthusiastic about science.

Ways in which teachers may be given assistance are numerous. Basic to any of these means is the knowledge that all teachers need encouragement and stimulation. Let leaders give of this unstintingly. Professions of interest and encouragement must be realistic to the extent of financing the program and educating skeptical parents to its acceptance.

Nan Lacy relates how the desirable methods for work with teachers in elementary science are used in developing a science program. Her account originally appeared in the *N. E. A. Journal*.

A Science Fair as a culmination project in one school may serve to motivate the launching of science study in another school.

Cleveland Public Schools

A Science Program—how it grew

"I've never tried to teach science because it isn't a required subject, and it takes all the time I have to teach reading, writing, and arithmetic. But after seeing this exhibit, I believe it might stimulate my pupils to do better language work. I see, too, how science can be integrated with other subjects."

"Well, I always thought science was something deep and difficult, but I believe I could try some of the things I've seen here."

These remarks were made by two teachers observing a science exhibit initiated, organized, and presented by a small group of Lexington, Kentucky, teachers. They had selected science as their curriculum study for the year. Every grade in the elementary school that had anything to show of a scientific nature was asked to participate.

During the visiting hours, some of the pupils who contributed articles were on hand to explain them. Representatives from a grade that had prepared a terrarium told how it was made. They also made brief explanations of the water cycle and the interdependence of plants and animals. A homemade barometer was displayed by a boy whose hobby was science.

At that time, only a limited number of teachers in Lexington were attempting any science at all. The committee hoped that, as a result of the display, more teachers would include science in their daily program.

Results of the Exhibit

Shortly after the exhibit, the supervisor found many new science corners in schoolrooms about the city. She found collections, aquariums, terrariums, and evidences of experimentation. A praying mantis, proudly displayed in a glass jar, was the subject of much discussion in one third grade.

More field trips were taken, and a few science clubs were organized. The educational value of leaves, rocks, or insects brought to school by children was recognized, and the interest was utilized to stimulate further study. Without realizing it, the children were expressing themselves effectively and at the

same time adding new words to their vocabulary. Several children found books on scientific subjects and read or reported from them. Pictures were drawn and colored and explained to the class.

For three years, the interest spread from grade to grade until at least three or four teachers in every elementary school in Lexington had some type of science activity. Practically all of this teaching, however, was incidental and often accidental.

The teaching staff experienced satisfaction that the science activities stimulated the children to do better work in other school subjects. However, they did not feel they were succeeding in developing a scientific attitude or in furthering the knowledge of science.

Evaluation and Development

The science committee, with some of the principals and the supervisor, attempted to evaluate their work. In analyzing procedures, the supervisor told of an invitation to a sixth-grade room to hear the pupils tell some facts they had learned about stars. They had used books and charts but had not considered going out at night to locate the planets and constellations they had studied.

Two nights later, she was returning from a school play when two of the pupils of that grade asked her if she would help them find some of the planets. She was painfully embarrassed to admit she could not help them. But she suggested they write to the University of Kentucky for permission to visit its observatory and study the stars through a telescope. Needless to say, she accompanied them on that trip.

That incident brought forth accounts of similar ones from the group. It was decided that in order to improve the science-teaching program:

(1) Teachers should make thorough preparations before starting an activity.

(2) Some facts must be learned from books, but many can be learned better by observation, experimentation, and firsthand information.

Other criticisms of the program were made, but it was decided that these two points should be stressed until some improvement was made on them. To remedy these weaknesses a greater number of field trips should be made, and more and better books and materials should be provided.

A teacher in each school was to survey her district to locate places that could be visited and the possibilities of science learning in her neighborhood within walking distance. Trips were taken to fields, parks, nurseries, waterworks, a museum at the University of Kentucky, and the observatory, with varying degrees of success.

Over a period of several years, the committee was constantly at work selling teachers on the value of science teaching. Teacher indifference and lack of self-confidence were great obstacles.

The Summer Session

Then, a plan extending the school year to 11 months for some pupils was adopted. The summer half-day session was to be for six weeks. All groups would be ungraded and under twenty in number. Afternoons were to be spent by teachers in plans and curriculum work. Based on classroom work, curriculum bulletins were to be developed.

Children were to be given work in any subjects needed, but the special fields to be stressed were selected by the staff. Science and language arts were the popular choices.

During the spring preceding the first summer school, the teachers who were to teach science in the summer session met several times to discuss their plans. They selected units of subject matter and the concepts they hoped to develop.

With their limited background, it was necessary to do intensive study to acquire the knowledge necessary to guide the pupils in their work. However, the summer school seemed to provide the ideal situation for teachers to improve their ability. The small classes and the time allotted for plans, gathering material, and evaluation enabled them to try new ideas and technics. Also, principals and the supervisor had more time to help.

The cooperation of the people in the community added much to the success of the project. One patron permitted the pupils

to use her backyard for a vegetable garden. Another invited the children to visit her flower garden. Some of the mothers who helped take the children on trips to community sources of science said they learned so much they wanted to go on every trip.

One day a primary and an intermediate group went together on a trip to the waterworks. The older group had made a thorough study of water. When some of the members of that group realized the engineer's talk was over the heads of the young boys and girls, they waited till he had finished. Then, in their own words, which were simple enough for the eight-year-olds to understand, they explained it to them.

Some trips and experiments were failures because not enough care was taken, all the materials were not ready, or the group had insufficient data from which to draw conclusions. However, one of the major aims of all the staff members was to impress upon the children the importance of building up a scientific attitude toward everything, and one or two instances convinced the workers that at least some of the children had developed it.

One group made some bread. They were interested in seeing it rise. When they were discussing it, the teacher asked them some of the facts they had learned. One child said, "Yeast always makes bread rise." Whereupon a little boy spoke up and said, "We don't really know that because we haven't tried to make bread without yeast."

Many wayward students who had not been interested in school before were stimulated by their science-class experiences and took greater interest in all their studies.

Popular Acceptance

The growth of the program sounds haphazard. Its development was largely through the nourishing of every little sprout of interest on the part of teachers and in helping it grow. No one could devote his entire time to this field. Even if there had been such a person, the staff felt that the work would be more effective if each teacher undertook it because of his own convictions rather than because it was superimposed.

The elementary schools of Lexington are still definitely in the readiness stage as far as the teaching of science is concerned.

Both teachers and pupils, however, now realize the importance of scientific understanding in the home, in business, and in the community. With that realization and the opportunity to learn new science-teaching technics every summer, teachers in Lexington hope to build a science program that will have continuity and will develop in pupils a better understanding of their world.

Teachers, supervisors, administrators, consultants and others working cooperatively through workshops, bulletins, science fairs, visits to classrooms where a program of science instruction is in progress and other avenues may eliminate fears and show ways to encourage the regular classroom teachers not only to undertake but to enjoy a program of elementary science.

Increase Your Understanding

1. Plan a complete program of help for teachers who wish to increase the value of science instruction in an elementary school.
2. Plan a science week end in your community developed around its scientific and human resources.
3. Make a list of the questions on pages 16–21 which you feel an elementary-school class might profitably attempt to answer.
4. Describe a series of not more than five experiments children may perform to find the answer to one of the questions on pages 16–21.
5. Select three series of elementary science books at any age level you wish. Compare the extent to which the respective books assist the teacher with the problem "How to Teach Science."
6. Ask the parents of several children what evidence they have of their children's need for science instruction.
7. List in separate columns reasons for your feeling of security and/or of insecurity for teaching science in the elementary school.
8. Interview three elementary-school teachers to find out why they fear to undertake a program of science or do not fear to undertake it.

Additional Readings

Blough, Glenn O. and Huggett, Albert J., *Methods and Activities in Elementary School Science*, The Dryden Press, New York, 1951. p. 4.

Craig, Gerald S., *Science for the Elementary-School Teacher*, Ginn and Co., New York, 1947. pp. 20–26.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 126–135.

Wells, Harrington, *Elementary Science Education in American Public Schools*, McGraw-Hill Book Company, Inc., New York, 1951. pp. 7–12.

Chapter 3

Why Utilize Experiences in Science in Educating Children?

One gains an understanding of why experiences in science should be utilized in educating children as one begins to understand the comprehensive meaning of the word science. Further understanding of the reasons comes as fears for undertaking a program of instruction in science are removed. Many people have expressed the purposes for teaching science. Their statements may be found in courses of study, professional books and magazines, and manuals which accompany series of textbooks in science.

Statements of Purposes for Teaching Science

The following statement[1] appears in a course of study:

> The purpose of instruction in science is to teach the pupil to live better in his environment or, more definitely, to guide the pupil during his school experiences so that he will intelligently use the truth of the past to take advantage of the opportunities of the future. This may be accomplished, in part at least, by a continuous program of scientific study throughout the pupil's school life. The following specific aims or objectives are suggested as a basis for good instruction in science:
>
> 1. Instruction in science should help create in pupils freedom from unfounded fears and superstitions, that is, develop in the pupil security in thinking brought about by a testing of ideas for truth.

[1] State of South Carolina, Department of Education, "Suggestions for the Teaching of Science in the Twelve-Year Program," Columbia, S. C.

2. The teaching of science should develop in the pupil the habit of seeking correct conclusions on the basis of evidence at hand.

3. The teaching of science should develop in the pupil an understanding of his environment and his relationship to the physical world.

4. Experiences in science should, at each concept level, have practical and cultural implications.

5. The teaching of science should help the child in making a wise choice in the use of products and by-products of science.

6. Instruction in science should create in the pupil an understanding in the use of scientific language at his concept level.

7. Instruction in science should encourage hobbies as a means of spending leisure time profitably.

8. Instruction in science should inspire in pupils an appreciation of the life and work of scientists.

9. Instruction in science should emphasize cause and effect relationships.

Another statement of the purposes for teaching science appears in a Curriculum Bulletin.[2] The five main points it makes are that instruction in science should help pupils to develop ability in solving problems and in critical thinking, to develop the disposition and the ability to maintain and use the scientific attitudes of mind, to develop insight into the interrelationships and interdependence among living things and the physical world, to develop an understanding of attitudes and habits conducive to good personal and community health and safety, and to assist in the development of a wide range of interests and hobbies.

A more simplified list of purposes for teaching science which is given in a manual to accompany a series of textbooks in elementary-school science is another example of statements which may be found.[3] It contains no new points. The list is as follows:

1. To develop the scientific attitudes, among which is an attitude of curiosity to find the answers to personal questions and of a desire to check upon the answers by various means.

[2] State Department of Education, "Science Education for the Elementary Schools of Ohio," Curriculum Bulletin No. 3, Columbus, Ohio.

[3] The Understanding Science Series, Teacher's Manual for *I Wonder Why*, The John C. Winston Co., Philadelphia, Pennsylvania.

2. To stir the child to an interest in his environment and its impact upon him.

3. To help the child feel more at home in his environment because he has begun to understand it.

4. To acquaint the child on his level of development with materials and information of science.

5. To build, little by little, the generalizations that underlie the world of science.

The reasons for utilizing experiences in science in educating children are basic to and embedded in the foregoing purposes and objectives. Here is another list of purposes that comes nearer to being a statement of reasons for teaching science. It is a series of traditional and clear statements. It is all-inclusive and has been accumulated from statements made at different times by elementary-school teachers and in books and articles.

Science is universal.

Science is something we live with daily.

The understanding of science means a richer, happier and fuller life.

Science gives a background for a more informed person.

Facts of science can become practical for the individual.

Through science we learn how to live.

The teaching of science is the best way to develop scientific attitudes.

Scientific knowledge is the best means for combating false or questionable opinions and will help clarify ideas about many happenings in our environment.

Children show intense interest in the world about them.

Children's questions indicate a genuine interest in science.

Science offers an avenue for satisfying children's interests.

Science helps us to know about the kinds of inventions and discoveries and thereby helps us to live better lives.

Materials are easily obtained for the study of science.

A person who knows science becomes more critical.

Science opens to the child avenues for the pursuit of a vocation.

Science offers opportunities for desirable hobbies.

An early interest in science leads to more serious study and to useful inventions and discoveries.

Science tends to offer answers to questions that arise from man's inborn desire for knowledge and truth.

Science develops social attitudes and appreciations.

Science enables the individual to meet the problems of existence with the available knowledge and requisite skill.

The development of scientific attitudes is probably the best means democracy has for perpetuating itself.

Synthesis of Purposes

An examination of the foregoing statements of purposes for teaching science shows overlappings as would be expected. It suggests the need for a synthesis or organization of the mass of details. It seems clear as one examines the statements that the reasons for teaching science are basic to the statements of purposes or objectives. The reasons for utilizing experiences in science in educating children can be summarized under such headings as these:

1. The universality of experiences in science
2. The child's need to satisfy curiosity
3. The child's need to gain the security which understanding brings
4. The vocational and leisure-time values of science
5. The need to make improvements in living
6. The value of using the scientific method in one's solving problems.

The Universal Presence of Science

The impact of science upon the daily lives of people of any age is everywhere in evidence. All children come to school with a background of experiences in science. They use words that have meaning for science and can name animals, plants and other objects. They have engaged in many activities that use the common facts of science. They have had many of their questions relating to science answered in whole or in part. Whether the child is from a rural or an urban environment, the teacher may count upon his background, no matter how meager it has been, to have been related in many ways to the world of science.

Wheelock College, Boston

The background of experience which children have leads them to ask more questions and with the help of an older friend, be it mother or teacher, to explore everyday occurrences.

Anyone may take a look at a series of personal experiences during a part of any day to help focus the picture of science as it surrounds him today. This is an example of such a quick look, and it could be duplicated by as many people as there are in the world for as many parts of any day as anyone would care to examine his experiences.

Mr. Smith looks at his watch and finds that it has stopped. He has not thought to wind it. A spring in the watch supplies energy to keep the watch running. Mr. Smith goes to the clock which is a part of the thermostatic control for the furnace that supplies central heating for his house. The clock is running, for the electric current from the community power house has been on constantly. Electricity supplies power to run the clock, to start the furnace and to light the basement when there is need to see if a fuse has blown out. It is time for Mr. Smith to start to work. He takes an overcoat, for it is winter as a strong wind

and drifting snow show when he looks through a window. The kind of clothes people wear depends upon conditions of the weather. The door through which Mr. Smith enters his garage squeaks as he opens and shuts it. Rust has caused friction in the iron hinge. Oil is used to reduce the friction and remove the squeak. Mr. Smith takes out his notebook and pencil to make a note to remind him that he must buy oil at the hardware store. In the car Mr. Smith turns on the radio to hear the news. A man's voice is telling about weather conditions over the Atlantic Ocean. Mr. Smith steps on the starter and backs his car from the garage, being careful not to let the fenders scrape against the door frame. That would scratch paint off and paint helps preserve his car. He gets out and easily pulls down the sliding door of the garage. He gets back into his car, turns on the heater and drives off.

Science is indeed everywhere and that is a reason for introducing an understanding of it into the curriculum of the elementary school. Such an exploration of science and the effects of scientific inventions as the one just recorded or one that can be made easily by anyone will be rewarding to a teacher simply because most people are unaware that every moment of every hour is permeated by science.

To show the contacts with science that a child living in a suburban section of a small southern town has, Julia Fussler, now of the University of Hawaii, Honolulu, formerly a kindergarten and primary teacher in various southern states, made a survey of a small section of Chapel Hill, North Carolina. The area surveyed extended only two blocks in each direction from Miss Fussler's home. After taking two weeks to make the survey, she found that these aspects of science would impinge upon anyone who lived in that small area and that they could easily be used, therefore, in developing a program of science in a school in that neighborhood. The report is given essentially as Miss Fussler made it except for a different arrangement of items.*

This survey is not intended to identify everything in the area, as the mass amount of everything in each field of science is too

* Used by permission.

extensive. It would be impossible in a two-week period to make anything like the full report that was made for the few minutes of Mr. Smith's day. Again it should be repeated that most people are only indefinitely aware of the science that surrounds them. General areas have been covered in this survey.

Trees:

Holly—berry bearing; elm; mimosa—powder puff like flower which closes at night, sensitive leaves; beech—bark, flowers, three-sided nut within prickly bur; arborvitae—bark, cones; hemlock—needle-like leaves; oaks—red oak, pointed leaves—black oak, lobes of leaves with shallow separation; blue spruce; tulip poplar; dogwood; maples—red and silver; linden; white pine—five needles; long-leaf pine; short-leaf pine; hickory; walnut; fruit trees—apple, pear, peach; forest.

Shrubs:

Cultivated—spirea, forsythia, wisteria, lilac, privet.

Vines:

Periwinkle, ivy, kudzu.

Flowers:

Cultivated—pansy, rose, tulip, jonquil, iris; wild—violet, pink, daisy, strawberry.

Animals:

Rabbit, squirrel, snake, frog, toad, terrapin; domesticated—dog, cat; birds—cardinal, wood thrush, hummingbird, song sparrow, catbird, quail, mourning dove, bluebird, Carolina wren, robin; insects—moths, butterflies, honey bees, wasps, hornet, mud dauber, house fly, horse fly, cockroach, mosquito, firefly.

Land:

Ravine; soil—clay, sand, loam; rocks—igneous, sedimentary, metamorphic; granite, sandstone, limestone, shale; elevation.

Water:

Stream; spring; city water supply; puddles; fog; rain; clouds—shape.

Atmosphere and temperature:

Suburbs cooler than in town; house cooler than outdoors; windows kept closed during day, open at night; attic hottest

part of house, basement coolest; electric stove for heat; refrigerator; moisture on body; evaporation; electric fan; expansion and contraction due to changes of temperature; thermostat; thermometers; wind—changes in direction.

Sound:

Birds' songs—cardinal, thrush, sparrow, bobwhite, dove, meadow lark; insects' noises—katydid, cicada, cricket, night insects; barking of dog; leaves rustling in wind; insects and birds flying; motor-oil furnace, refrigerator, automobile; honking of cars; telephone bell; humming of electric clock; clock ticking and striking; vacuum cleaner; floor creaks; night cooling causes parts of house to creak; click of doors; insects striking house; bell tower; roar of traffic on highway; people talking and singing; radio; thunder; objects being hit together.

Light:

From sun; reflected light; moonlight; starlight; lightning—streak, sheet; lightning bugs; flashlight; car lights; electric lights—fluorescent, mazda; candlelight; light from burning match; reflections in mirrors; twilight; night; dawn; sunset; colors—red, yellow, blue, green, orange, violet, indigo; shadows; window shades.

Electricity:

Radio; telephone; electric light—plugs, sockets, switch; electric clock, stove, refrigerator, iron, toaster, percolator; lightning; motor; flashlight; vacuum cleaner.

Materials:

Wood—mahogany, oak, maple, cedar, pine, walnut; fabrics—cotton, silk, wool, rayon, nylon, felt, canvas; leather—calf, kid; rubber; metals—iron, steel, chromium, gold, silver, copper, bronze, pewter, aluminum; glass; china; brick; concrete; mirrors; foods.

Preservation:

Canning; preserving with vinegar; freezing; painting; varnishing; waxing; cooking; protecting with mothballs; watering flowers and grass.

Machinery:

Springs—clocks, doorknobs, screens, watches; wedge—knives, axes; inclined plane—screw, meat grinder; lever—scissors,

pliers, pruning shears, hammer; wheel—sewing machine, mowing machine, bicycle axle, door knobs; gasoline engine; automobiles; steam engine; oil furnace; electric motor—refrigerator, washing machine, vacuum cleaner; balances with weights; saws; flight of birds and insects; movement.

Changes:

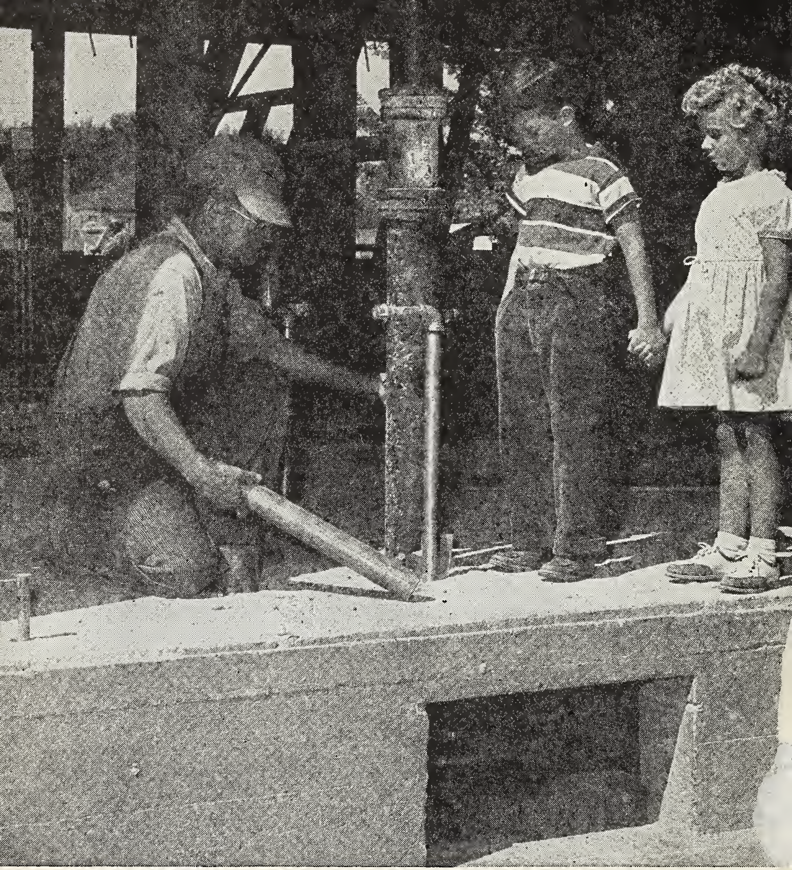
Clouds moving, changing shape; grass turns brown; young birds leave nest; nests built by birds and insects; temperature; weather conditions; growth of plants.

As one examines the items in the survey that has been reported, it becomes evident that Miss Fussler knew much science to begin with. It is equally evident that other items probably could have been included. Some of the ones that might be included are safety devices, efforts to conserve the soil, houses, roads and sidewalks, electric light poles and wires, the human body and many, many others. The point is that science is always around us but that most people are unaware of its presence. One reason for utilizing experiences in science in educating children is that more people may become aware of the impacts of science upon them.

Satisfying the Child's Curiosity

Science, perhaps more than any other school subject, provides many opportunities for the diversification of activity to meet varying levels of growth. This is important, for today there is an unusual amount of attention given to the study of the growth and development of children. Teachers are constantly being urged to enlarge continuously their knowledge of how children grow physically, mentally, socially and emotionally. Individual differences among children should never be neglected. It should, furthermore, never be forgotten that growth does not occur in separate stages but that it is continuous and takes place at varying rates.

One well-known need of children, one that varies with different children and in accordance with the individual child's background of experiences, is that of having their curiosity satisfied. No one can say what the individual child's area of curiosity will be at any given time or in any given community. It will be true,



Denver Public Schools

A child's curiosity, to be satisfied, will often involve an area of science.

however, that his curiosity will be more likely to center itself in some aspect of science in the environment than in anything else.

In science workshops at the University of Nebraska, Kenneth Freeman directed the work of participants in an attempt to bring a closer relation between the characteristics and needs of various maturity levels of children in the elementary school and the suggestions for the improvement of instruction. The members of the workshop were experienced teachers. Their goal was a

concise, ready reference to show directly and clearly this relationship between developmental characteristics and curriculum. They decided to present the results in a two-column format, the first column listing developmental characteristics of certain age groups and the second column listing the appropriate experiences in science. The results of their work are presented fully in Chapter 4.

The group listed curiosity as one of the characteristics of children at all grade levels, but it must be noted that children differ in the degree of curiosity as they do in all aspects of readiness for learning. These differences show clearly the need for a wide diversity of activities in teaching science.

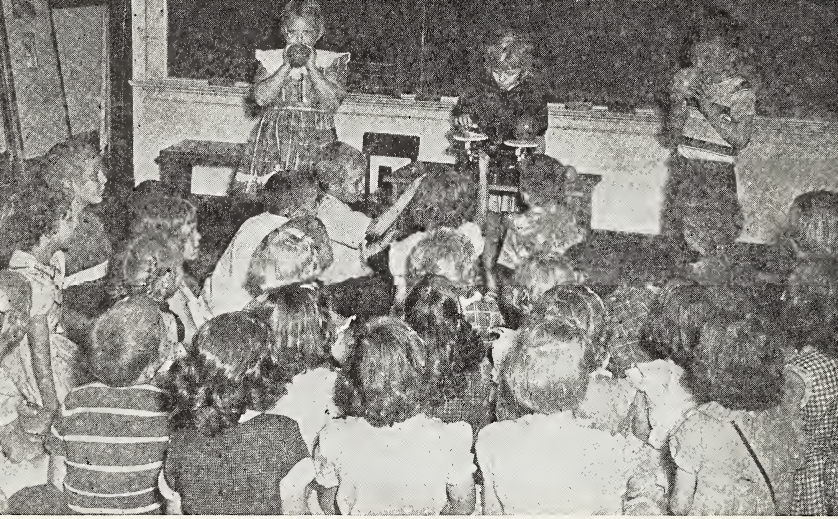
If children should be interested in the study of air, possible activities to provide opportunity for diversification would be the following:

1. Make pinwheels and hold them in the wind. What happens?

2. Suspend a yardstick from a string tied around the center. From one end of the yardstick suspend a balloon, the top of which is wrapped with a rubber band. Fasten a paper clip to the rubber band and slip the clip over the yardstick. Balance the balloon by placing some other object on the other end of the yardstick. Then take the balloon off and blow it up. Now replace it on the yardstick. Is it heavier or lighter? Why?

3. Fill a rubber tube with water by laying it in a pan of water. Carefully pinch one end shut and lift it over the edge of the pan so that the end is over another pan which is lower than the first pan. Keep the other end of the tube in the water. What happened when you released the end of the tube? How does man apply this principle?

4. Make a mercury barometer, using a dish, some mercury and a 32-inch glass tube which is closed at one end. Fill the tube with mercury. Tap the tube gently on the table to expel the air bubbles. Put some mercury in the dish. Holding your finger over the open end of the tube, invert the tube. Place the open end in the dish of mercury. What happens to the mercury in the tube? Measure it.



Murray State College Training School, Murray, Ky.

Weighing filled and unfilled balloons is another experiment which can be performed to show that air has weight.

The illustrations, of course, show the possibility for diversification in only one area, that of satisfying curiosity about air by experimentation. The fact remains, however, that science should be used in educating children because it offers more possibilities than other areas of learning for satisfying their curiosity on many different levels of development.

Security through Understanding

Another well-known need of children, and one again that differs for different children in accordance with the individual's background of experiences, his learning rate, his interests and his maturity level, is that of gaining an increasing feeling of security. Science is particularly effective in offering opportunities to gain security through understanding. Quackery, superstitions, and perversions of the scientific method may be eradicated through a forthright program of instruction in science.

Many children are afraid of toads because they have been told that handling toads causes warts. Toads could be handled, records could be kept and the results discussed. A superstition would be removed, and the child would feel more secure.

A teacher in the schools of Cincinnati has related how a little boy in her classroom had brought the story to school that playing with one's shadow causes bed-wetting. The teacher did not say, "Oh, no, it doesn't," but took advantage of the opportunity to have children experiment with shadows. The children went onto the school grounds at different times of the day and played with shadows, measuring them and studying them generally. A discussion the following day showed that no bed-wetting had taken place after playing and working with shadows. The little boy was eager to inform the one who had told him about bed-wetting being caused by playing with shadows that she was wrong.

Many children and many adults, too, are afraid of storms and lightning until they begin to understand the nature of wind and static electricity. Eclipses of moon and sun disturb those who do not understand the motions of earth, moon and sun. Often people are afraid to replace a burned out fuse with a new one. Harmless or even useful snakes are killed along with poisonous ones because of a lack of understanding which the program of science could bring. The list of false beliefs could be extended almost indefinitely.

A reason for utilizing experiences in science in educating children is that through them security may be gained. Not only a knowledge of the facts but the use of the scientific method itself brings security through understanding.

Vocational and Leisure-time Values of Science

The program of science in elementary school, high school and college has often brought leisure-time occupations that have high value to the one who engages in them. Science clubs, exhibits in museums and at school or commercial science fairs, and reading about science have also often contributed to the development of interesting hobbies. Two boys seeing an exhibit of blueprints of leaves at a science fair at once wanted to learn how to make blueprints and that led into making other kinds of prints. That hobby lasted for them for over a year. Belonging to an Audubon Club has made many an amateur ornithologist. Carefully labeled and classified collections of shells, feathers,

rocks, butterflies, kinds of soil, wild flowers, leaves, fossils and other items have been made and are constantly added to as a result of school work in some aspect of science. Interest in airplanes, stimulated by trips to airports and by pictures, has often led to the hobby of constructing model airplanes. It would be possible to list an endless number of examples of the value of science experiences in stimulating worthwhile leisure-time activities.

In the elementary school one should not expect definite decisions upon vocations but often abiding interests have been started there. In high school and college one does expect guidance and decisions in vocations. Science is, of course, not the only field of subject matter which leads into vocations, but it is an important one. Electricians, radio and television experts, engineers, doctors, nurses, dieticians, chemists, geologists, mechanics, agriculturists, conservationists, astronomers, "fix-it" men and women, and countless other people have vocations which stem from science and make use of the facts and principles of science.

Many people who are not primarily engaged in vocations that make use of science or whose hobbies and leisure-time occupations are not concerned with aspects of science are able to understand items of interest in newspapers and magazines which are scientific in their nature because of having had school courses in science. Often one hears the expression, "I wish I had had courses in geology, astronomy, chemistry and other fields of science so that I could read about new inventions and discoveries and new applications of science with more understanding and know more about the world about me." Not only is science universal but reports on its applications to industry and to general improvements in living are ever in the news. Those who know something about science find that their reading becomes more significant for leisure-time enjoyment.

Leisure-time occupations and specific hobbies are important to all people no less than are vocations. Both are practical and both lead to appreciations. Since science can contribute so greatly to them, the reason for introducing it into the school curriculum is clear.

Improvements in Living through Science

Pure science may stop with the discovery of facts and principles. The program of science in too many schools stops with parrot-like repetition of facts and principles that have been memorized to receive credit for school work. It is not enough merely to know. The true scientific method leads on into speculation as to the meaning of the fact or the principle. An important reason for utilizing experiences in science in educating children is that more satisfying conditions for living may be brought about. James Harvey Robinson has stated in general terms this underlying thought. He says, "The new methods employed by students of natural science have resulted in the accumulation of a stupendous mass of information in regard to the material structure and operation of things."[4] And, again, "Human efforts should be directed to make the lot of humanity progressively better by intelligent reforms in the light of advancing knowledge."[5]

Science could and should be used to improve daily living. Improvements in the production, preservation, transportation, preparation and conservation of man's food supply are dependent upon applied science. Applied science has resulted in better control of disease and extended the life expectancy of man. Science has been brought to bear upon improved methods of communication, ways of travel, and the production of raw and finished materials. It has improved modern man's attitude toward things by relieving him of many superstitions and fears. A look at some areas in which spectacular improvements have been made in conditions of living will emphasize the point. It will also show how easily the program of instruction in science can be carried beyond mere knowledge of facts and principles into the realm of their application to betterment of human welfare and how obligatory that extension is.

The homes of men have been revolutionized by the application of the facts and principles of science. All children live in homes of some kind and even the most unimproved of those

[4] Robinson, James Harvey, *The Mind in the Making*, Harper and Brothers, New York, 1921, p. 137.

[5] Ibid., p. 157.

homes represent enormous steps in man's progress from the time of the tree dwellers and cave men. It is unfortunately true that many children who have been exposed to instruction in science have little understanding of the marvelous work of inventors and pure scientists in using science to improve social conditions. They have learned the facts of science, as they often learn facts of geography, history, literature, and other content subjects or the skills of reading, spelling, language usage and mathematics without extending those facts and skills into social significance.

Units of work and other similar attempts to make a unified approach to learning justify themselves from the fact that they do not stop short with memorization of facts, either unrelated or arranged in logical patterns. A unit of work on *Modern Homes and How They Came to Be*, or any unified approach to the subject, would consider every aspect of their development. Materials for construction of the building itself, lighting, heating, supply of water and furnishings would be considered. The facts and principles of science would contribute to the general story. Raw materials may be fused chemically and by heat to make bricks, concrete and glass. Light rays pass through some substances. An electric current produces light and heat under described conditions. Heat may be produced centrally and distributed over a building by blowing, radiation or gravity. These are only a few of the facts of science that would be used. Inventions to improve the amount of light, the distribution of heat, sanitation, and methods of work essential to homemaking would be studied along with the reasons which brought need for improvement. The method of work of the inventors and the need for further inventions would form a part of the study of the development of homes. Homes are different in different regions of the world because of different conditions of climate, different sources for building materials and different social customs. The furnishings and decorations of homes differ for the same reasons. Costs for building homes vary. All these items not only imply knowledge of the facts and principles of science but an understanding of man's efforts to improve living by applying them to his problems.

Safety and health have been improved through the use of science. Tools, electricity, chemicals, fire, plants, animals are

all potentially dangerous materials. It is desirable to develop a wholesome appreciation of their hazards rather than fear of them. This can be done by teachers and parents who know the facts and principles of science. Children have a natural tendency to explore their environment. It is the responsibility of teachers and parents or other leaders to help them recognize poisonous plants and to know what to do if they come into contact with such plants. Some animals are dangerous and through training in science people can be helped to recognize conditions which invite danger from them. Electric currents, chemicals and fire can be used safely and controlled if the facts about them are known. Sharp tools will cut, heavy tools will fall and pointed tools will stick into objects. All factories are required to use devices which protect the employees from danger. Automobiles and other machines are equipped with safety devices. Highways and many public places display warning signs. In all this there is concern for the protection of people because injuries interfere with human welfare. Disease interferes also with human welfare. Doctors, nurses, public health clinics, school health rooms and departments of health in communities have all been developed for the betterment of social living.

Throughout the elementary school, physical and mental health as affected by sleep, rest, fatigue, diet, exposure and drugs can better be explained to the pupil and made a part of his daily life through training in science. Safety, as affected by trips, construction work and the use of apparatus and materials, can also be explained to the pupil and made a part of his daily life through training in science. It is the responsibility of teachers who use experiences in science in educating children to make sure that the social implications of safety and health are not neglected.

Many facts and principles of science underlie improved practices in conservation of natural resources as well as of human life. Farmers are now conserving soil by building terraces, contour plowing and planting and cover crops. Houses built of wood are kept painted. Tools and machines are oiled and kept under cover. Insulating materials and many devices have been invented to conserve heat. Toys and playthings are items of

considerable expense to parents. The need for frequent repairs and the occasions for general deterioration are more excessive than need be. Teachers may well capitalize on this situation for such teaching as the use of simple machines, the causes of friction and the care of machines to eliminate wear by friction. Conservation of clothing and of school equipment and supplies also is important and should be used by teachers in their program of instruction in science. This places the teaching of science in settings familiar to the children and draws on their experiential background. It becomes a natural means of motivation for understanding many of the facts of science. It appeals to parents, for it has social significance. No lead into an understanding of the need for conservation should be neglected.

Of all the subjects included in the school curriculum, science probably provides the most natural opportunities for extending home and community experiences and, by so doing, providing for cooperation between the home and the school.

Other examples of the social significance of instruction in science could be assembled at will. It will become evident, too, as the examples are accumulated that, in spite of all the widespread developments which have come about, modern man has not realized even a fraction of the potential improvements made possible through the application of modern scientific developments or which could be made possible. A reason for the utilization of experiences in science in educating children is that more individuals may live effectively in today's world and make their contributions to the proper social control of scientific discoveries so that others in increasing numbers may have that same advantage.

Values in Using the Scientific Method

The individual uses his mind to understand natural phenomena and to make use of the principles that are discovered. The ways in which reliable understandings are arrived at most efficiently make the scientific method.

The scientific method means stating problems clearly; gathering data through experiments, careful observation, and analysis of records previously made; keeping careful records; making

inferences and drawing conclusions from data; testing and retesting the validity of data; and applying the conclusions to practical situations. It means also the willingness to admit new data whenever they are found and to restate conclusions in the light of these data.

The application of the principle arrived at through the scientific method to the solution of social problems means growth for individuals and for society as a whole. The application of the scientific method helps each person in the solution of his own individual problems, and it helps society solve its larger problems.

Democracy is a much overworked term. It means different things to different people and in different cultures. Essentially it means the right of individuals who make up a society to seek evidence in support of hypotheses, to express opinions freely, to find opportunities to develop without fear, and to be respected as individuals. It means also that each individual expects every other individual to have the same rights as he demands for himself.

Democracy is based upon changes that make the individual of most worth to himself and to society. The individual grows and changes. So, too, does the society in which he has a part grow and change. Democracy is a form of society developed by individuals to make their own growth more satisfying and to give their initiative in creativeness ever-expanding outlets. By its nature it cannot remain static. Individuals and social groups alike live in an environment. Not only does each adjust to the environment but each also seeks to change the environment to make it more satisfying to individual and social needs. It is the environment and adjustments to it and changes in it that challenge human beings to use their minds. Life for good or ill remains tied to its surroundings. The scientific method begins to find its place for worthy use in a democracy because of the individual's relationship to an environment. The importance of the scientific method receives emphasis because of its bearings upon changes.

Thomas Jefferson once said, "I have sworn upon the Altar of God eternal hostility against every form of tyranny over the mind of man." A lack of scientific knowledge and a lack of

facility in using the scientific method and of maintaining scientific attitudes are tyranny over the mind of man. The preservation of social life in a truly democratic form depends upon a wiser and more universal use of the findings of science. This conception of the role of science in the preservation of social life in a truly democratic form includes the use of scientific facts and the scientific method for the solution of international, as well as national and individual, problems.

One should hasten to say that the discoveries of science do not always provide complete and final solutions to all problems. In fact, they very frequently raise more difficult problems than men had previously met and dealt with. A case in point is the whole field of atomic energy. The necessity for the wise use and control of scientific discoveries and inventions is clearly seen. Here the stage is set for introducing ways of developing the scientific method among all participants in any social values attendant upon the growth of democracy.

Meeting Objectives

It is insufficient that teachers know the reasons for utilizing experiences in science in educating children. It is not enough to make glowing statements of objectives based upon the reasons which seem valid. Common practice in classrooms often does not correspond to statements of objectives or purposes in teaching science.

Chapter 11 in this book is devoted to evaluation of the worth of a program of science, but at this point it seems useful to point out a few practices which do not correspond to objectives which reasons for teaching science soundly support.

Often courses of study or textbooks in science are followed slavishly from beginning to end. Children who bring in objects which interest them or who ask questions not on the assigned subject matter are told, "We do not have time to talk about that. We must cover the course of study. Our book must be our guide." Different words would be used probably, but the import of them would be the same. The child's curiosity is not taken as a reason for teaching science. It is one of the reasons basic to many of the statements of objectives. Always it deserves

careful consideration. Teachers do find it confusing, often annoying, to have well-made plans pushed aside. But if the child needs to have his curiosity satisfied, time must always be taken to do it, either immediately or at a later definitely set period.

Often the teacher performs all experiments and states all the findings from them. The teacher also often arranges all bulletin boards and takes complete charge of apparatus and materials. "Oh, I can do it more quickly and better and I do not make a mess," is the explanation. Although the value of doing or of being active about learning was not given as a reason for teaching science, it applies to all learning. Science cannot be done without activity if there is to be more than memorization of what the book or the teacher says. Furthermore, if children are to be led to leisure-time and vocational interests, they must practice them. Still further as an argument against the teacher and perhaps one child being the only active members of a class, security could never be gained by children unless they handled apparatus, specimens and materials. The scientific method is never learned

Handling specimens and arranging bulletin boards are some ways of gaining security in science endeavors.

Louisville Public Schools, Louisville, Ky.

merely because it is used by another person. It is learned by being used over and over. At times, of course, an experiment must be performed by the teacher. The nature of the apparatus used or of the experiment itself might make it necessary. Bulletin boards and supplies should be kept in order, but children learn order only when they have opportunities to bring it about. In general the objectives for teaching science will not be met unless all members of the class have opportunities to perform experiments and to check results by performing them over and over again if necessary. They will not be met unless children arrange bulletin boards, exhibits and all manner of illustrative materials and help keep apparatus and materials in order and accessible for use. The teacher may act as an expert guide but never as the sole performer in meeting the objectives of a program of science.

It is a well-known truism that if children are ever to learn the scientific method, they must use it. Problems must be their own and be of consequence to them. Teachers have a difficult job in trying to give opportunities for each of the members of a class of twenty to thirty or more children to work on individually significant problems. It usually is only when the whole class group finds some project that has various aspects in which individuals take interest, or when specific periods during which each can carry on solutions to his own problem are provided, that the difficulty can be overcome. The scientific method will not be practiced unless the child wishes to solve his own problems or problems that he finds of worth to himself.

Often instruction in science becomes instruction in pure science. The children do not have experiences in applying in actual situations what they have learned or of seeing applications of it in the community. The program of instruction in science in the elementary school should be practical, and it should lead into social understandings and appreciations. "We have no space for making a garden," is a common statement, sometimes even when the space can be seen clearly by the interviewer interested in making practical applications of learnings in science. The same kind of escapist excuse is given about having children in a regular classroom cook a meal at school, keep a pet, or plant shrubs and trees to prevent erosion. "It takes too much

time from regular school work to help the community clean up vacant lots," is another common statement. The community is the most logical place to choose for examination if one wants to see the facts and principles of science being applied. It is the source for appreciative understanding of how the contributions of science are being used to improve human welfare. The doors of classrooms must be opened and the walls almost destroyed if the objective of making improvements in living is to be met. A part of the program of instruction in science should be community-centered. Such activities as making a garden, keeping pets, preventing erosion on school and home grounds, setting out trees and shrubs or helping with the landscaping at home or at school, managing and constructing safety devices, planning and preparing meals, making apparatus for experiments and equipment for classroom or school, keeping schoolroom and grounds clean, and contributing workers to community campaigns for cleanliness, safety and health should be a part of every school. They belong particularly to the field of science and help realize one of the goals of teaching science.

Often in schoolrooms one may hear the expression: "The book says so." It may be slightly changed to "My mother says so," "The teacher says so," or "Mr. Jones says so." It is clear that the children are relying on one source for evidence. The scientific method implies consulting many sources for evidence. Many books, many interviews, many observations, many experiments are essential for building the attitudes of open-mindedness, suspended judgment and constant searching for evidence. A successful program of teaching science in the broad meaning of that term cannot be carried on without supplies, equipment and willingness to seek abroad and to mingle with community living.

Summary

Experiences in science should be utilized in educating children because:

1. Science is universal and makes a tremendous impact on the daily lives of all people, both children and adults.

2. Science has great value in meeting the needs which children have to satisfy their curiosity.

3. A knowledge of the facts and principles of science and a use of the scientific method bring security.

4. Instruction in science leads into worthy leisure-time and vocational occupations.

5. Science provides probably the best avenue through which to approach the problem of improving human welfare.

6. The use of the scientific method is necessary to maintain a truly democratic form of society.

Increase Your Understanding

1. Clip all articles about science appearing in your daily paper for a week. On the basis of this activity what would you conclude about the impact of science on our daily lives?

2. List the reasons for teaching science that appear in your own city and state course of study. Do you think they are good ones?

3. Keep a record for a week of the personal problems you solved by application of a scientific method.

4. Review some of the recent literature on the elementary-school curriculum and be prepared to quote five authorities on the importance of science in the elementary school.

5. Keep a record of your activities for any five-minute period. Analyze the record for impacts of science upon you during the period.

6. Does a use of the scientific method destroy moral standards and moral precepts? Prove your point.

7. Why would the use of a single textbook or a single reference book in science defeat the objectives in teaching science? Which objectives would be defeated?

8. How has the application of the facts and principles of science changed agriculture or commercial entertainment?

9. Describe a program of science which you have engaged in either as student or teacher. How nearly was it based on the six reasons given for teaching science?

Additional Readings

Blough, Glenn O. and Huggett, Albert J., *Elementary-School Science and How to Teach It*, The Dryden Press, 1951. pp. 12–22.

Caswell, Hollis L. and Foshay, Wellesley A., *Education in the Elementary School*, American Book Co., New York, 1950. pp. 138–146.

Craig, Gerald S., *Science for the Elementary-School Teacher*, Ginn and Co., New York, 1947. pp. 3–19.

National Society for the Study of Education, 40th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 19–38, 41–60.

Chapter 4

Children's Readiness for Science

Readiness as a term came into the educational vocabulary as a result of efforts to delay reading in the first year of school until a child was mature enough to desire to read and to have other prerequisite abilities to enable him to learn to read without aversion. Readiness means purpose and mind-set for learning of any kind, as well as for learning to read. It depends on many factors such as physical condition, background of experience, emotional adjustment, and mental ability. General readiness to learn would usually imply readiness for science.

Readiness applies to all age levels as well as to children who are beginning their school career. Children in pre-school years become ready for many kinds of learning because their background of accumulated and immediate experience, their environment, their purpose, their physical and mental needs, and other factors impel them. Readiness to learn does not end with pre-school or first year in school. It continues throughout life. Teachers are always faced with the responsibility to investigate a child's readiness for learning new skills and information on any level of his development. An objection to a planned-in-advance program of instruction in science is that willy-nilly all children in a classroom are expected to learn specified subject matter whether each is ready for it or not.

Although readiness for learning involves many factors, and although no one would be justified in selecting single factors in determining readiness, it is possible to select factors which relate

specifically to learning certain kinds of subject matter. Learning to read, learning to write, learning to perform experiments, or learning any special skill or body of information, each has its specific as well as the general aspects of readiness to be considered. The intent in this chapter is not to consider general aspects of readiness, except to indicate that they are important, but to look at readiness for instruction in science.

The background of a child's experiences and the situations which can be set up in classrooms to lead into readiness for science are the areas which the teacher particularly should investigate. To say that in no way minimizes the importance of investigating the child's physical condition, his emotional and social adjustments and his mental ability. In no way does it minimize the importance of finding out whether the child has other requisite skills such as ability to read, to array evidence in order, to speak to a point or to write when there is need to write. Readiness for instruction in science in its broadest implications of meaning has specific aspects that can and should be investigated.

Some children are clearly ready for instruction in science when they enter the first year of school or when they enter any year of school, just as some of them are ready to read or to acquire other skills and information. Some need other experiences which will lead them into readiness for learning science.

Contacts with Science

Teachers know from experience that all children have had pre-school experiences from which readiness for learning science facts and generalizations could easily arise. They include naming things, learning words related to science, doing things, asking questions and looking at pictures.

The Pre-school Child Names Things

Already upon his arrival at school each child, no matter what the environment from which he comes, has an equipment of language. His language in large measure is made up of names for things and activities in his environment. Doggie, daddy, mama, mother, father, brother, sister, flower, bird, car, light, bell,

ding-ding, honk-honk, water or variations upon those and probably several hundred other names of objects, animals and experiences belong to him. They are answers to his first questions. They have started his acquaintance with his environment. The rural child may of course have his specialized knowledge such as cow, horse, cotton, plow, mule, pig, and barn. Equally the urban child has his specialized knowledge such as elevator, street, subway train, skyscraper or even escalator. This equipment of language not only means readiness for reading but readiness for science. The teacher can make use of it.

The Pre-school Child Knows the Meaning of Many Words Used in Science

The pre-school child knows the meaning of many other words that have close relationships to science. He knows hot, cold, dark, light, soft, hard, heavy; he knows sour, sweet, large, small, fast, slow, up, down, loud, still, moving; he knows pull, run, walk, swim, roll, move, stand, drop, fall, hold, rub, burn, sting, wash, cook; he knows telephone, switch, electric iron, hammer, saw, paint, bus; and he knows see, look, hear, taste, smell, feel, touch. There is no need to list other words, for each parent or teacher can do it. The more extensive the child's experiences, the more he has been brought into contacts with his environment through trips, conversations and explorations, the more he has questioned and been answered, the greater will be the number of words he knows. The good teacher will have given readiness tests for vocabulary and will have a thorough understanding of his language equipment and will be ready to use it in helping him to learn reading, spelling, science or other areas of school experience. The extent of readiness in language for science can be positively determined by any such investigation.

The Pre-school Child Has Done Things

There is no normal child who has not engaged in activities that could lead into knowledge of science. Many children have cooked something. Wise parents have let them turn the egg beater, mix batter for cake, stir candy syrup or jelly, bake Christmas cookies, or wash and dry dishes. Children have

turned on the lights, answered the telephone, ironed doll clothes, and toasted marshmallows over an open fire. Mud pies have been made and castles in sand have been built. Many children have run the carpet sweeper or vacuum cleaner; opened the refrigerator or the oven; put food on a bird feeding tray or fed a pet; watered flowers in window boxes or pots or gardens; run through a spray of water; made soap bubbles; spun and wound up a top; picked up tacks with a magnet; constructed some sort of playhouse. Some have had building blocks and electric trains or construction sets. Pets have been seen, if not cared for. Most children have gone on picnics and taken trips of one kind or another. The good teacher who is looking for meaningful leads into teaching science can usually count upon a background of activities. This background of experience with doing and making should be explored for each individual child in the group. It is a part of readiness for teaching science.

The Pre-school Child Asks Questions

The small child's questions are often distracting to parents and other adults, but, if the child is not repressed and finally made to be silent and if his questions are answered on his level to the best of the adult's ability, the child gains an equipment of facts and meanings that make beginnings in science easy. At first the child wants to know what this or that is. He may be seeking only attention, but he is also accumulating names. Questions about what is being done by this or that worker, whether man or beast, come along later. "How does it do that?" or "How does it work?" come later still. Interspersed with "What's that?", "What is he doing?" and "How does it work?" come such startling questions as: Where do babies come from? Is there a Santa Claus? Where do fairies live? Who is God? The environment in which the child lives will determine the kinds of questions he asks. The occasion for asking the question cannot be predicted with certainty. The child's mental development, the encouragement he has had to ask questions freely and to receive answers that satisfy him, and the point to which his curiosity has developed will influence both the kind of question he asks and the occasion for asking it.

Wise parents and teachers will answer the question truly, using names that are used by adults and giving whatever facts are needed to satisfy the particular child at the level of development he has reached. They will not take refuge in taboos of modesty, nastiness, secrecy and prejudice. It is wise not to subject the child to ideas and tales that lead into realms of fairy tale and metaphysics which are beyond even adult understanding. Some of the interspersed, startling questions mentioned above have been brought about because of adult prepossession to please and entertain immature minds. If the child does ask questions, he should not be put off because some adult considers it immodest to want to know about parts of the body, nasty to want to talk about natural bodily functions, unnatural to want to know about where one originates, or irreligious to explain God as the source of good.

The quality of the child's question improves if care is taken to make trips into stimulating environments, to provide play and constructive materials that require ingenuity to manipulate, and to suggest the further learnings that may come from other trips and manipulations. Every kind of environment and every kind of activity may lead into science.

The Pre-school Child Looks at Pictures

Only one example of the stimulation that picture books and pictures found in magazines give to science learnings will suffice to show what the teacher may count upon for readiness in science from the use of pictures by pre-school children. A copy of Mother Goose[1] selected at random has pictures of twenty-five different distinctive animals. Earth, sky, water, sun, moon and stars are in it. The seasons, snow, rain, clouds, every kind of weather, indeed, even the pictures for each month of the year are in it. A seesaw, wheels, scissors, a sled, a ladder, candles, tongs, a tea kettle on the stove can be found. Baby animals, eggs, birds' nests, plants of many kinds, and varied occupational activities and workers are pictured. That one book is a treasure house not merely of delightful traditional verse, but of background material from which the child makes closer contact with science.

[1] *The Tall Book of Mother Goose*, pictured by Feodor Rojankovsky, Harpers, 1942.

In using picture books the word science may not be used at all, but the fact remains that science is there and the child accumulates readiness for more of it.

The Home Itself Is a Laboratory

Although, as in the use of picture books and pictures in magazines, the word science may not be used in connection with all kinds of activities carried on in the home, the fact remains that any home is a laboratory in which the facts and techniques of science are seen and otherwise experienced daily and almost hourly. The kitchen, the furnace room, ventilation, heating, selection of proper kinds of clothing, removing stains, the bathroom, water and electricity, refrigeration—these are all sources for much direct contact with science. It remains only for the teacher to explore their possibilities and to recall the child's experiences with them to start him into further explorations.

Developmental Characteristics of Elementary-School Children

The characteristics of pre-school children discussed above on pages 58–61 indicate the necessity for a comprehensive knowledge of developmental characteristics as we prepare to appraise readiness at different levels in the elementary school. Some teachers have found it helpful to study these characteristics to discover periods of readiness for certain types of experiences. The following report records the results of such a study.

It should be re-emphasized that developmental characteristics are applicable only in a general way and that individual differences among children in any group must always be considered in determining the kind of activities which are proposed for different age levels.

It should be noted also that such an activity as making a collection can be carried on at many levels of proficiency. Children even of pre-school age make collections of a sort. The collection is a bringing together of things, unclassified and often unclassifiable. As the child develops, the quality of his collection improves. At ages 8 and 9 some labeling of items in a collection may be expected of some children. Often children at ages 10 and 11 have well-classified collections.

Developmental Characteristics	Science Implications
For 6 and 7 year olds	
1. The urge for constant physical activity is great, causing fatigue. Periods of interest are relatively short.	1. Opportunities for care of pets in the classroom; caring for plants, and fish in an aquarium; going on short, well-planned excursions and dramatic play could serve to satisfy this urge. Plan many varied experiences.
2. Muscular development is uneven; ability to use small muscles is limited.	2. Science activities should involve large muscle activity, such as building inclined planes out of blocks. Comparison of drag and pull with and without wheels. Opportunity for manipulation of large things, for example: building airplanes or trains.
3. There is a questioning attitude toward his immediate surroundings and the concrete. He is very curious.	3. Studying and experimenting with work-savers, for example: Wheels, wagons, hammers. Levers used to lift weight. How can a man lift a big hunk of concrete sidewalk with an iron bar? The child's intellectual life develops rapidly during this period. Curiosity about how things work is a big drive. A teacher who is sensitive to children's expressed curiosity in a selected field can capitalize this to sustain and foster interest. Notice different animal homes. Make simple collections.
4. The child at this age is becoming group conscious in work and play. The competitive spirit of these ages often leads to bickering and arguments about things; yet this	4. Group planning for dramatizations, science corner, and excursions can foster good group interaction and a spirit of helping each other in learning.

For 6 and 7 year olds

Developmental Characteristics	Science Implications
is the process by which the child identifies himself as an individual and develops working relationships with others.	
5. He wants to become self-reliant and independent, but still turns to parents and teachers for much help.	5. At this point a teacher must be alert to the small responsibilities a child of six or seven can carry well. He can be encouraged to experiment with magnets and observe habits of pets for himself. In this way he gains confidence in self-reliance.
6. He develops fears of things he does not understand.	6. Explore the helpful nature of things feared. Discover how fire helps people; how wind helps people. Provide for pleasant experiences with things feared. "Who says toads will give warts?" Observe and study the habits of a toad.
7. Work and play with others to satisfy personal desire. There is limited ability for cooperative work.	7. Each child's relationship to the teacher takes precedence over his relationship to other children. Therefore, he will follow the teacher's leadership easily. A teacher aware of this will avoid situations and activities which will damage his natural curiosity and investigative nature.
8. He is capable of simple reasoning about things concerning his own immediate surroundings. Gradually during this period the question "What is it?" is supplanted by inquiries bearing on cause and effect.	8. Science provides many opportunities for observation of seasonal changes in the world about him. Weather affects the activities of boys and girls. Comparisons can be made between things familiar to him and others in his immediate

For 6 and 7 year olds

Developmental Characteristics	Science Implications
	surroundings. Take nature hikes to observe changes in the same thing at different seasons. In the language of the children, record these changes in their environment. Keep a simple weather chart.
9. He likes to dramatize many things.	9. A teacher can use the imaginative play and dramatization to discover gaps in knowledge. It is also an avenue for instruction, such as in playing the work of the postman, the farmers, aviators and the habits of animals.
10. Boy and girl interests are separating as shown by the activities each prefers.	10. Boys especially like to take things apart to see how they work. An excellent way to learn how clocks are made is to take one apart. Girls like to play house.
11. He is developing a rudimentary understanding of time.	11. Activities of day and night can be observed. Seasons and their effect on animals can be studied.
12. He is self-assertive and agressive. He does much boasting.	12. For young children adequacy comes through successful experiences. Experiments should be kept simple.

Denver Public Schools

Developmental Characteristics	Science Implications
For 8 and 9 year olds	
1. Children of this age group collect all kinds of things.	1. Make collections of leaves and seeds. Notice the different ways seeds travel. Collect insects, flowers, rocks and grasses. These may be labeled.
2. The child of this age is very curious.	2. Allow satisfaction in participation in the solution of early and very simple problems of children that their curiosity about things can develop into deeper curiosity that will grow. "What makes it rain?"
3. Eye and hand coordination is becoming good.	3. More near work can be done and more detailed experiments can be performed.
4. There is a growing capacity to read for information and a lengthening of the interest span.	4. More reading can be planned to supplement the observation period.
5. Extreme motor activity is shown. Small muscle development is more complete.	5. Longer excursions can be planned; more construction work in experiments can be done, such as, building bird houses and making wind vanes.
6. There is a broadening interest in people and the community.	6. Provide science experiences which show how people use machines, plants, and animals to help them make living more comfortable. The immediate community can provide a rich laboratory for observation through excursions. Individuals in the community can be called upon to show how something is made or done.
7. High interest is becoming evident in experimentation with actual objects and materials.	7. Opportunity for much experimentation should be provided together with some reading about how to do them. Experiments with a switch, a dry

For 8 and 9 year olds

Developmental Characteristics	Science Implications
	cell and a battery in electricity; making candles; rust, nails in glass of water, toys left outside, garden tools, and larger machines left in the fields.
8. Interest is not so confined to immediate surroundings and himself.	8. Activities can take in studies about the earth, moon, and stars. A study of the movements of the planets can be made.
9. There is an awareness of classmates both as individuals and members of the same school and group.	9. Children need some interpretations from adults, but it is likely children will learn from each other if we will free them more to observe and experiment in the world around them.
10. He becomes much aware of changes in immediate physical surroundings.	10. Constant observation can be going on of changes brought about by seasons, time and weathering. One or two specific things can be watched and records kept.
11. Boys begin to like rough and tumble play. These children have a great amount of energy, and boys especially like to show their physical "prowess."	11. Nature hikes provide profitable means of dissipating this energy.
12. He continues to like dramatization and imaginative play.	12. Science experiences can be used. Children can impersonate the sun and earth in working out the relationship of these bodies.
13. He likes to work and play in groups.	13. Go outdoors often. Watch for opportunities to build concepts: some soils are better for growing plants than others. Leaves and stems of plants die and help make good soil.

Denver Public Schools

A chance puddle by the side of the path offers an opportunity for building many concepts.

Developmental Characteristics	Science Implications
For 8 and 9 year olds	
	Some plants look as if they are dead, but their roots may be alive. Weeds are plants, but they often grow in wrong places.
14. Fears are still present. Most of these fears are superstitions acquired from the family and community.	Study science facts about matters of superstition, as: toads make warts, making faces and striking clocks. Study useful and interesting phases of objects of superstitions. Join a school garden club.

Developmental Characteristics	Science Implications
For 8 and 9 year olds	
15. He is becoming more competitive, self-assertive, and independent. His allegiance is to the peer group instead of to the adult in case of conflict.	15. Provide opportunities to be out of doors and visit a variety of places—a garden plot, a meadow, the edge of the woods, a deeply wooded area, a field, a rocky place, or a wet near-swampy place.
16. Interest in own pets and their care is strong.	16. Keep a terrarium. Study habits of animals and birds. Set up a classroom zoo.
17. Boy and girl interests are continuing to separate very widely, often to the point of antagonism between boy and girl groups.	17. Emphasize physical science. Both boys and girls are interested in this area. Both groups are active in Cub Scout and Girl Scout or Camp Fire work. Knowledge gained in the work in these groups can often contribute to class activities and break down antagonisms.
18. There is a tendency to do what others in their own age group are doing, great enough to weaken established codes.	
19. There is a growing curiosity about the facts of reproduction.	19. Studies of living things, insects, snails, animals, birds, and plants provide many facts of reproduction. Experiments and experiences in watching cocoons hatch, animals and their young are helpful. Films in this area can be obtained. Most animals take care of their babies. Some animals need a great deal of care; other babies take care of themselves. Watch tadpoles.

Developmental Characteristics	Science Implications
For 10 and 11 year olds	
1. Muscular growth is rapid, producing laziness, awkwardness and fatigue, making a very changeable person in interests and behavior.	1. Science experiences should be planned to avoid fatigue. Observation and making collections provide activities fitting into this developmental stage.
2. Boy and girl interests are still separate although eleven-year-olds are again becoming interested in each other.	
3. Interest in people, community, and affairs of the world becomes more keen, especially in the eleven-year-old.	3. Plan activities investigating how people of own community are influenced by their own type of climate and geography. Also day to day, season to season influence of weather on their own community as well as that of country and other countries and people can be investigated. Much reading can be planned in this area at this age level.
4. Eyes are almost adult size and are ready for near work.	4. Some children at this age enjoy making detailed drawings and illustrations. Science activities requiring them can be done by such individuals. More detailed observations in selected areas can now be done. Make charts of the solar system.
5. This age group is inclined to become overcritical of each other, adults, and the surroundings in general.	5. Scientific approach to problem solving and using the scientific method provides an outlet to test ideas.
6. Group loyalty is strong. To act and dress like the rest of the group is very necessary to keep up personal prestige.	

Developmental Characteristics	Science Implications
For 10 and 11 year olds	
7 The child of this age has a keen sense of right and wrong, which often disagrees with codes of society in general.	
8. He continues to like to collect almost anything.	8. He can make collections of birds, pictures, leaves, flowers, grasses, insects, bark and woods. He enjoys making rough classifications of his collections.
9. Personal prestige is vital at this age. His social development depends on being accepted by his group.	9. Teachers can make a point of discovering what each can do well or takes pride in doing and give opportunities for the group or a few individuals who need that particular skill or information to do these things.
10. He likes to work with concrete and factual materials.	10. Provide extensive and enlarged experiences in actual cooking of foods; using hammer, saw and screw driver to build things; simple electrical circuits.
11. Talents and skills become more definite. Children in a group quickly recognize these in each other.	11. Suit science activities to meet individual differences in skills and talents. Leadership can be fostered at this age level by having children work in smaller groups with a leader.
12. He begins to be able to plan activities and budget time more carefully.	12. Groups of this age level can plan some types of activities quite well, especially if activities revolve around a point of high interest to them. Care must be taken that they do not plan in a wave of enthusiasm a project requiring too long an interest span. Have a science center.

For 10 and 11 year olds

Developmental Characteristics	Science Implications
13. Curiosity about facts of reproduction is heightened.	13. Study life cycles of plants, insects, animals and their young. Observe these on excursions. Many good films showing reproduction at various levels can be obtained. Raising hamsters, white rats and fish helps to answer questions about reproduction, diet, animal growth and care. Make and keep charts up to date on food experiments and changes in the young hamsters or other animals.
14. Can attend to visual tasks at the same time maintaining conversation.	14. This makes possible the manipulation of discussion or telling activity needed to work out science problems.
15. Questions usually now begin with how, what, when, where, who.	15. This makes possible the formulating of questions about a problem of interest. It helps the teacher plan the scope and direction a selected science project will take.
16. He is careless about his personal appearance. This is more true of the ten-year-old than the eleven-year-old.	16. Science experiments which require exactness are helpful. The learning experiences in connection with planting a "bacteria garden" will be beneficial.
17. He is becoming erratic in choices of food.	17. Factual experimentation with diet and white rats will be of profit here. Investigation of what food does for the body with good illustrations and charts and many films will be of great interest at this age level.
18. He's more interested in displaying own individual skills	18. Individual as well as group projects.

Developmental Characteristics	Science Implications
For 10 and 11 year olds	
with little interest for team games at ten. More interest in team games begins at eleven.	
19. He is always in a hurry to do things of interest to himself.	19. When opportunity arises, a science activity should arise out of the interest shown by the child. He will be more likely to complete such projects.
For 12 and 13 year olds	
1. The child of this age group is now concerned more with the real than the fanciful.	1. Do experimenting in science which shows actual facts as plant growing, showing need of light and water. Have seeds sprout. Make telephone and telegraph sets.
2. He is becoming more proficient in generalizing and in making deductions.	2. Records can be kept of facts discovered, with the teacher fostering generalizations and deductions from them. Observe and record temperature, wind direction, barometric pressure, clouds and forecast weather from the facts observed.
3. He is much concerned about what other people think of him. Group values still take precedence over adult values, but a more adult-like sense of values is in the process of development.	3. Investigate ways how to get along best with others. Dramatize these situations. Etiquette for the pre-adolescent can be investigated, using actual situations he meets for the problems. Much reading can be planned in this area. Personal success is possible for everyone. Science problems challenge and test ability to succeed.
4. He is very much interested in team games.	4. Science clubs can be of great interest to this group. It can

For 12 and 13 year olds

Developmental Characteristics	Science Implications
	be another activity which will add to the satisfaction of his teamwork desire.
5. Rapid uneven growth causes enormous appetite, laziness, restlessness, awkwardness and fatigue resulting in less energetic work at lessons.	5. Health and diet problems may be the basis of study to help the child understand himself. Experimenting with diet and animal growth to show what food does for the body is of interest and value. Work out problems in mental health, such as "What to do when disappointments come."
6. Consciousness and pride in personal appearance are becoming very evident.	6. Part of the science program can include a unit on good grooming. Helpful hints on choosing becoming clothing can be given both boys and girls. Actual demonstration can be worked to show this. A study of the care of the skin and hair will be profitable. These studies can be made by a class or a smaller group.
7. He is still individualistic, but competition and ideas of sportsmanship appeal to him.	7. He can be helped to realize that people can disagree without quarreling. In solving science problems he discovers that scientists often have different points of view and that people usually make their own deductions but do not always agree. However, they can at the same time respect the opinions of others.
8. There is a great tendency to begin many projects without finishing them.	8. Opportunity should be given for many short experiments which hold interest easily. Experiment with solids, liquids, and gases. Air pressure:

For 12 and 13 year olds

Developmental Characteristics	Science implications
	Turn a bottle filled with water upside down in a pan of water to show it will not empty. Other experiments of this nature can be done when interests are of short duration.
9. He is becoming more skilled in problem solving.	9. They learn to solve problems and find answers as scientists do by experimenting with such problems as: How can one material be changed into another? Why do you eat different kinds of food? How do magnets work? Study of the compass is made more understandable through simple experiments with bar-magnets, magnetized needles and others. Make a crude compass.
10. He fights against the demands of obeying the rules of time and space.	10. Study the planets to show how their movements are bound to time and space. Keep a record of the variation of daylight and dark hours as they change with the seasons. Study reasons for the accuracy of bus, trains, and planes. Schedules may be investigated. Incubation periods of various birds can be observed. Each child can make a schedule of his own routine. Study the problem: How does my schedule affect the lives of others?
11. Reading interests become distinctly broadened.	11. Individual interests may be met and developed through

For 12 and 13 year olds

Developmental Characteristics	Science implications
	making science books and magazines available.
12. Interest in own pets continues. Boys especially show strong attachments for pets.	12. Study of animals of special interest to individuals or groups will hold much attention.
13. He will camouflage his feeling from the family. He is striving to become independent; yet, in many ways, he feels he is inadequate.	13. Undertake a unit of work or a unit of subject matter in which interdependence of living things is emphasized. Discover inadequacies which bring about dependence as: A cow needs plants to live. Undertake a unit of work about "Understanding Yourself." Note that all people feel inadequacies. Find out what can be done about them.
14. He is careless in language and work. Language ability is developing, but slang is often used because of peer values.	14. Words and expressions are used to impress others. Science experiments and studies open a field of vocabulary that could serve the same purpose as slang if the child masters the use of science vocabulary. Examples of words that offer outlets equivalent to those offered by slang are: Atomic energy, atoms, magnetic attraction, calories, soluble and insoluble.
15. Affectations are often assumed, especially by girls.	
16. He resents teasing and criticism of friends.	
17. Boys and girls have "best friends," but are inclined to transfer devotion to a new friend suddenly.	17. Friendships change because interests change often at this age. As a part of the study, "Understanding Yourself," investigation and observations as well as reading can

For 12 and 13 year olds

Developmental Characteristics	Science Implications
	be done to discover what makes people become friends. Be sure to point out that the process of growing up changes people's interests as well as their bodies.
18. There is evidence of strong superstition.	18. Provide opportunities for investigating scientific facts concerning the points of superstition. Through the scientific method pupils can prove to their own satisfaction that the well known superstitions about the groundhog and the rabbit's foot are faulty reasoning.
19. He enjoys the concrete type of manipulation. He likes to see exactly how things work.	19. This work can be done with science experiences.
20. Attention is easily distracted, and he has difficulty in concentration.	20. Keen interest will overcome this trait.
21. He is inclined to interpret criticism of teachers as personal feelings against him.	21. Teacher and pupil working together with science experiences will find a change in this attitude.
22. He has a keen interest in small jobs to earn money.	
23. He is moody and unstable. He is preoccupied with acceptance by his social group; is fearful of ridicule and being unpopular; is sensitive and given to self-pity and moodiness.	23. Committee work and group demonstrations provide for some social needs among their own group.
24. Can draw conclusions from things observed.	24. Encourage pupils to evaluate experiments and observations.

Teachers should know the children with whom they work. A guide to the characteristics which are prominent at different age levels, such as the foregoing extended list, should help in

deciding upon what to expect from children who in general have arrived at the different levels. It will also indicate avenues through which readiness for different aspects of the program of science may be produced.

At the end of the list, as at the beginning, it should be emphasized and re-emphasized that children develop at different rates. The causes for such differences in rate of development are partly inherited traits. They also can often be found in limited backgrounds of experiences, different procedures to which the child has been exposed at home and at school and differences in physical care.

Evaluating Readiness for Science

Except for tests of vocabulary and language usage in general, means to find out a child's stage of readiness for science and to discover the value of that readiness must be devised by the teacher. Simple means can be found for doing it and the teacher can assure herself that the child is ready to go forward in his accumulation of knowledge and his use of the facts.

It is extremely doubtful whether the child on entering school can give completely satisfying answers to questions such as these:

1. What is an animal?
2. How is the shell useful to an animal?
3. How are trees different from each other?
4. What is a season of the year?
5. Are changes in the weather due to atmospheric conditions?
6. What makes milk run to the floor when it is spilled?
7. What changes does cooking make in food?
8. Why does a saw rust when it is left outside?
9. Why do wheels make work easier?

The teacher who knows children would not expect such factual information and would not ask the questions. There should be positive evidence, however, that the child is able to use the facts inherent in the questions. The teacher seeking means to evaluate the child's readiness for further experiences in science would find out how he used those facts of science in everyday activities in the schoolroom and other places. The setting inside the classroom would soon begin to give evidence of the worth

of the child's pre-school experiences with science. The teacher can easily keep a record for the children about whom she is doubtful as to their readiness to go forward with science. The record could be organized around these points.

Reaction to Living Things—Pets and Plants

Use of Tools and Materials

Awareness of Weather and the Need for Changes in Clothing to Suit Conditions of the Weather

Personal Health Habits

In order to make the keeping of such records more meaningful and easier, the teacher might organize each larger area into items that could be checked for individual children.

Teachers would not find it worthwhile nor would they have time to apply a great number of tests to show readiness for science. General readiness tests indicate in part readiness for science. A few of the following items would be enough to show lack of readiness for science, or rather a need to have more experiences which would make a particular child ready.

Many items have been given as indicative of lack of being ready, and teachers will profit from noting what they are. Since only a few children in any group are likely to show many lacks, the teacher's job will not be burdensome, even if the lists of items under the larger areas seem formidable. The lists of items are mainly suggestive of experiences which all children should have.

Reaction to Living Things—Pets and Plants

1. Is interested in pictures of plants and animals. ....
2. Wants to help care for pet. ....
3. Pays no attention to the pet we have. ....
4. Pokes at the pet and disturbs it. ....
5. Watches the pet at times and seems to be observing its actions. ....
6. Pulls plants out of the pots or boxes. ....
7. Wants to care for the plant. ....
8. Brings plants or parts of them to school. ....

9. Never mentions plants or animals at home. ....
10. Is afraid of animals. ....
11. Often brings items of interest about plants and animals at home. ....
12. Pays no attention to the plants. ....

One reason for keeping a pet of some kind in the schoolroom and for having growing plants there is to give the teacher a chance to explore the child's readiness for additional experiences with both plants and animals. The pupils should be encouraged to help care for the plants and animals, for many reasons, of course, but partly for this one that is being discussed—the evaluation of the child's readiness for science. If the child had never been allowed to help care for living things, to allow it and to help him do it would be a prerequisite for his introduction to more experiences with them.

Use of Tools and Materials

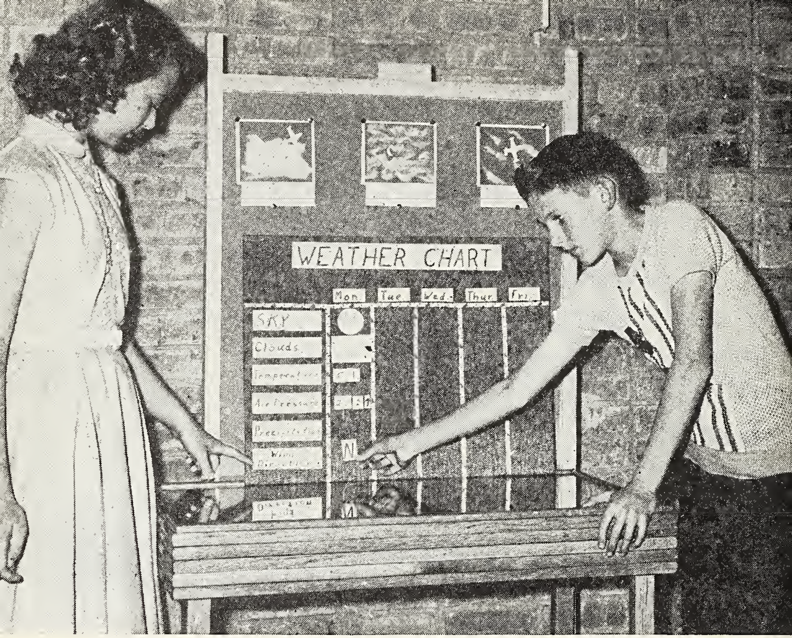
1. Cannot use a hammer to drive a nail. ....
2. Does not know how to use a saw. ....
3. Cannot use a paint brush without getting covered with paint. ....
4. Piles blocks one on another without planning. ....
5. Has little physical coordination so that he cannot handle small objects. ....
6. Leaves lids off jars of paste and paint. ....
7. Does not take care of tools after he has used them. ....
8. Does not know how to use a seesaw. ....
9. Seems not to know about a thermometer. ....
10. Uses tools rather skillfully. ....
11. Can pile blocks according to a plan. ....
12. Is careful in handling paint brush. ....
13. Replaces all lids on jars and all tools, checking that they are in the proper place. ....

14. Can place articles on the bulletin boards. ....
15. Is intelligently curious about our science apparatus. ....
16. All playground equipment is used as it should be. ....
17. Expresses curiosity to know about such things as light .... switch, ventilators, bells, moving picture machine, toilet facilities. ....

One reason for having the schoolroom equipped with a varied assortment of tools and materials is that the child can manipulate them and begin to show to the observant teacher his readiness for learning about them or his need for experiences with them as a means of stimulation of interest in them. A schoolroom that is bare of tools such as hammer, scissors, needles, saw, screwdriver, vise; of apparatus such as magnets, light switch, prism, dry cell, jars, scales, electric hot plate and outlet for current; of supplies such as nails, tacks, rubber bands, paste, paints, paper, wood, clay, cloth; of equipment such as seesaw, slide, swing, workbench, motion picture machine, filing cabinet, typewriter—a room that has only erasers and chalk—will not offer much incentive for explorations that will lead to the use of scientific principles or to the accumulation of facts of science.

Awareness of Weather and of the Need for Changes in Clothing to Suit the Conditions of the Weather

1. Does not notice the kind of day. ....
2. Does not talk about rain, snow, frost, fog or other manifestations of weather. ....
3. Does not notice the thermometer. ....
4. Never mentions change of costume on account of weather. ....
5. Must be reminded to put on clothes before going outdoors. ....
6. Is interested in weather. ....
7. Wants to make the weather chart and knows what to put on one. ....
8. Talks about change of clothing due to weather conditions. ....



Battle Creek Public Schools

The weather chart stimulates readiness, at any age, for learning more about various aspects of weather and challenges the boys and girls to ask questions and to devise simple experiments to answer their questions.

One reason for keeping a daily weather chart is to stimulate readiness for learning more about the weather. Although the child may not talk about sunshine, rain and snow, he is probably aware of them. In only a few days of planning for and making weather charts the teacher can find out which children are prepared to participate meaningfully in the period and which ones need experiences in the varied kinds of weather to make them ready for any more learning in connection with it.

Personal Health Habits

1. Does not wash his hands after using the toilet. ....
2. Picks at his nose. ....
3. Puts objects in his mouth. ....
4. Cannot tie his shoe laces. ....

5. Does not choose food wisely. ....
6. Does not eat green vegetables. ....
7. Seems not to take care of personal possessions. ....
8. Seems to be aware of the need for personal care. ....
9. Knows why soap is used. ....
10. Can arrange his own clothes. ....
11. Eats the right kinds of food. ....

One reason for the teacher to investigate personal health habits is that they show whether the child is using the laws of science in caring for himself. He may not know at all that he is using science, but he is properly attending to health habits and the teacher can assume that he is ready for further experiences that will lead to an understanding of what he is doing.

The teacher will be able to think of other ways to check upon her class for readiness in science. If the children ask questions that seem to lead into science, if they bring specimens from the environment and wish to tell about them, if they want to talk about books of science, if they look at pictures which have leads into science, if they use a vocabulary that shows acquaintance with the ordinary environment and man's adaptations of it and to it by means of science, they are ready for a general approach to understanding of science and to generalization.

Questions as an Indication of Readiness for Learning

Any modern approach to learning makes use of the student's interest in the topic or problem. The questions that students ask are probably the best single indication of readiness for learning because they usually show interest.

Groups of experienced teachers have suggested the questions that children have asked. The following questions have come from the memory of such teachers. They cannot be depended upon to be strictly accurate, but they are exactly given as the teachers reported them at various times. They represent all levels of growth in the elementary school. They represent also the questions some teachers themselves wish answered.

1. Why do roots go down instead of up?
2. Why am I afraid in the dark?
3. How far away is the sky?
4. Where does the rain come from?
5. How do we know the world is round?
6. What makes the rainbow?
7. Where do butterflies come from?
8. Why does a ship disappear from sight when it is crossing the ocean?
9. How long does it stay dark where the Eskimos live?
10. Where do babies come from?
11. Just exactly how does water power turn into electricity?
12. Who made God?
13. Why didn't the trees in the petrified forests of Arizona rot before they turned to stone?
14. What makes shadows get longer and shorter?
15. Why is it hotter in the middle of the day?
16. What makes it rain?
17. How did water and coal and oil and other things get down in the earth?
18. How could a worm be a butterfly?
19. Where does the sun go when it goes out of sight?
20. Why do the biscuits brown when put in the oven?
21. How do we grow?
22. Why does smoke go up?
23. Why does it hail sometimes when it is so hot?
24. Why does the sun shine in the daytime and the moon at night?
25. Why are there stars in the sky?
26. Why do bears sleep all winter?
27. If the earth is round, why don't the people on the other side fall off?
28. Where does the old cat get her baby kittens?
29. Where are the stars in the daytime?
30. How high can an airplane fly?
31. What makes the sky blue?
32. How, if the atom cannot be seen, can scientists make a drawing of how an atom appears?
33. What makes plants grow?
34. Why does it rain?
35. Do frogs cause warts?
36. How do sound films work?
37. If you cut a snake in two, will the parts grow back?

Children in the intermediate school present an additional problem, for the teacher must determine how much science instruction they have had and how effective it has been. By the time a child has reached the fourth year of school, for example, he may be expected to have accumulated a large store of simple generalizations, factual information, and an extensive vocabulary if he has participated in a science program. At this point the teacher should find it profitable to do some pre-testing with simple teacher-made tests to determine the status of the group and individuals in regard to generalizations, information and vocabulary. A good science program emphasizes the development of problem solving. Children should be tested to determine their present ability to apply the scientific method to their own problems. There will be great variability within the group; consequently, the readiness program must be individualized.

Checking Readiness for Word Usage

The following list includes words with special import for science that will normally be a part of the work of the primary years of school. There will be considerable overlapping for individuals, but the words or similar ones appear in the best-planned programs as indicated.

First year

boil	hammer	rock
cocoon	magnet	seashore
collection	moon	seed
earthworm	mountains	shadows
experiment	nails	shell
feathers	pinwheel	tools
goldfish	questions	weather
		young

Second year

amount	bloom	direction
answer	calendar	dry cell
aquarium	clock	electric
balance	different	engine

evaporates
fruit
gasoline
height
insects
lever
machines
magnifying
mechanical
motors
museum
observe
pod
prism
protect
pulley
rainbow
ray
record
scales
seasons
shape
siphon
size
snowflake
sound
stalk
steam
storm
switch
tadpoles
temperature
thermometer
toad
trip
tube
ventilate
weight
wire

Third year

alum
apparatus
ashes
backbones
blueprint
bottle
brakes
compass
contracts
copper
crank
curious
divisions
draft
expands
experiences
ferns
flask
friction
groups
handle
inventor
liquid
mammals
melt
microscope
moths
perform
pitch pipe
pressure cooker
proof
reflected
refrigerator
reproduce
reptiles
rods
science
scientists
spores
stem
stopper
superstitions
surface
teaspoon
telescope
television
tuber
vapor
vegetables
wrapping

Samplings of the vocabulary for other years of the elementary school may be devised from courses of study, or manuals of adopted texts. Any lack of familiarity with the above words would necessitate the planning of experiences designed to clarify meanings prior to any use of them.

Checking Readiness for Generalizations

A comprehensive list of generalizations to be developed in the elementary school may be obtained from various sources. Their complete reproduction here does not merit the necessary space. The following brief illustrations are provided:

First year

Seeds are made by plants.
Seeing is a way to find out.
Hearing is a way to find out.
Asking questions is a way to find out.
Experimenting is a way to find out.
Animals do not all move in the same way.
Sunshine is warm.
Shadows change with the time of day.
Wind is air that is moving.
Air and wind cannot be seen.
Tools help people work.

Second year

Seeds travel in different ways.
Plants and animals grow and change.
Seasons are not all alike.
Some birds are useful.
Usually many carefully planned experiments and observations are needed to find answers to questions.
Wind is caused by differences in temperature.
Cold air is heavier than warm air.
Warm air rises.
A ray of light is made of many colors.
Light travels in straight lines.
Evaporation of any liquid from your skin makes your skin cooler.

Third year

Heat makes water evaporate.
Living plants reproduce themselves.
Animals reproduce themselves.
Living things need food, water and air.
Heat changes materials.
Friction makes materials wear out.
Friction is sometimes useful.
Human beings are mammals.
Scientists use experiments to find answers to questions.

Samplings of generalizations appropriate for other years may be collected from lists, texts, manuals and courses of study. Efforts to explore this specific readiness for science must be supplemented by a general inventory of intelligence, language ability and social competence. There are many ways of solving problems in science, one of which is reading from authoritative books. This direct relationship shows how reading ability is an indication of one kind of readiness for one kind of learning experience. Ability to work cooperatively is essential to much group experimental work in science. Teachers will wish to explore all these related areas of readiness.

Evolution of Concepts as a Form of Readiness

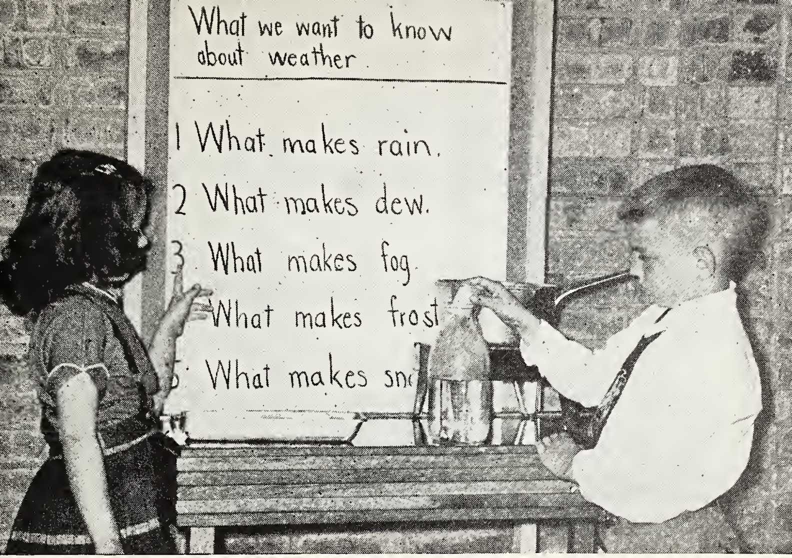
The term *water cycle* is an abstract term which identifies an extremely important phenomenon in nature. When can children use and understand such a term? What does one do to get children to deal with such a concept? The evolution of simple generalizations developed through real experiences to provide readiness for the understanding of the water cycle may be as follows:

First Year of a Program of Science

Weather charts picturing rainy days, windy days, cold snowy days, and sunny days are shown. Wind blowing wet clothes is shown and followed by appropriate discussion. An experiment to show how a cloud is formed is performed by boiling water in a teakettle.

Second Year of a Program of Science

Discussion of snowflakes. Answering the question, "We are always having to pour more water into the aquarium. Where does the water go?" Perform an experiment by placing water in a shallow glass dish where some sunshine will fall on it. Place another shallow glass dish of water in a shady place. Does the water evaporate from each dish? Does it evaporate faster from the dish that was placed in the warm place? Experiment with air and wind, learning relative weight of hot and cold air and the effect of temperature on air movements. Pupils learn heat



Battle Creek Public Schools

Experiments to show "What makes rain?" may be performed in the third year of a program of science.

and wind make water evaporate faster. An experiment is performed to produce steam.

Third Year of a Program of Science

An experiment to determine if water rises from a flask into a glass tube when heated. Observation of evaporation of water from uncovered paste in the schoolroom. Reading about making maple syrup by boiling sap to evaporate water from it. Observe and study use of pressure cookers. Four easy experiments given to illustrate each step of water cycle (term itself not yet used) to answer question "What Makes Rain?" Read for the answer to "Why does water not cover all the land?" Explanation of existence and formation of water vapors.

Fourth Year of a Program of Science

Study evaporation and condensation in steam heating system. Changing water from gas, to liquid, to a solid. Explain water cycle by discussion and demonstration. Make a chart to illustrate the water cycle.

Developing Readiness for Science

People, in general, are surrounded by the world of science. Often they are not aware of science at all. Using household gadgets, turning off electric lights, using the telephone, riding on buses or trains, using an elevator, riding in a car—all are closely connected with science and the ways it works, but people pass them by with mere use. If one wished to find out the stage of readiness for learning more about electricity, one would investigate the previous experiences that had been had with electricity. A preliminary period of readiness at any level of pupil growth might be necessary before the study of the topic could be made profitable. People would need to be reminded of previous experience just as children would before entering upon a study of some aspect of science. The submerged background of contact with science in its varied services would have to be called forth. That is providing for readiness to learn more at any level.

The world is a world of science and man's applications of the laws and materials of science. Houses, clothes and food are laws and materials of science turned to man's uses. Means of communication all depend upon the laws and materials of the natural world. Air, water, and energy are there in the environment if man wishes to turn them to his use.

No lack exists, from the point of view of the environment itself, for readiness for science. Often the child or the adult has not been made aware of his environment and of the laws that operate in it. The teacher will need to investigate, to look about for additional meaningful contacts, to draw out the whole background of experience, if use is to be made of the child's readiness for science. On occasion the teacher will need to set the stage so that readiness for understanding and using the laws and materials of the natural world will arise. It is the easiest kind of readiness to develop simply because the world of science is inescapable as long as one is alive.

Increase Your Understanding

1. Select a book for pre-school children such as *The Tale of Peter Rabbit* or some other book and analyze it for picture and text content with value for readiness for science.

2. Suggest a list of fine trade books that parents may give children to create an interest in science. Are there any cautions to be exercised in the use of this kind of material? Explain.

3. Prepare a checklist to be used by teachers in making an inventory of the experience background of first-grade children which contributes to readiness for science.

4. Prepare a pre-test of science information and generalizations to be given to children entering the sixth year. Suggest profitable uses of such a test.

5. Visit a classroom four different times during a school year and describe for each trip the physical aspects of the room that would contribute to readiness for science.

6. *Studying Children—Diagnostic and Remedial Procedures in Teaching* by Theodore L. Torgerson, Dryden Press, New York, is an excellent handbook for teachers interested in the problem of studying children in relation to readiness. Many other books, written expressly for that purpose, are usually available in professional libraries for teachers. Investigate either Torgerson's handbook or another one covering the area of general readiness and report upon the comprehensive way in which studying children is presented.

Additional Reading

Craig, Gerald S., *Science in Childhood Education*, Teacher's College, Columbia University, 1944.

Hefferman, Helen, *Guiding the Young Child*, D. C. Heath Co., Boston. pp. 85-93.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 78–87.

Using What We Know About Children—Science Learning, *Childhood Education*, Vol. XXVI, No. 7. Washington, D. C., Association for Childhood Education International.

Chapter 5

Planning and Organizing for Improved Teaching

IMPROVED teaching is certainly the result of no accident. This chapter applies to science, in a practical way, workable theories for planning and organizing for improved teaching.

The teacher of elementary science must hourly, daily, weekly, and yearly make choices of goals and content and of method. Although many persons may in some way help the teacher in making these choices, a considerable amount of the responsibility rests ultimately with the teacher and the pupils with whom he works. The greatest aid to the teacher in meeting this challenge effectively is to do adequate planning. There is no sound place in good teaching practice for impromptu improvisation as a basic approach to helping children learn. This does not imply that the teacher's plans are rigid or inflexible to the extent that children have so little opportunity to participate in the planning that the purposes and values of the work do not become their own. Providing educative experiences in science requires as much if not more careful planning than in dealing with any other subject. Some of the reasons for this are the relative unfamiliarity of the teacher with science, the newness of science as a subject in the elementary-school curriculum, the frequent necessity to lean heavily on community resources for instructional materials, and the knowledge and general readiness of children in this area. The implication is that the teacher's planning will result in an extensive knowledge of the curriculum,

the community, and the children in the classroom. It will also result in improvement of instruction.

Getting Acquainted with Children in a Classroom

One of the traditional aspects of the American public school system generally interferes with a teacher's development of the real knowledge and understanding of the children in her room. Many teachers feel that they are teaching a grade; that is, grade one, two, three, four, five, or six. This term "grade" is supposed to have some mythical connotation which makes it possible to meet the needs and interests of a varied group of children by presenting experience for "graders." Curriculum planning too often involves experiences for first graders, second graders or fifth graders.

What is a grade? It is not a group of pupils who are similar in intelligence, reading ability and personality characteristics. The typical grade is composed of pupils who vary from five to seven years in mental age and in which pupils with the same I.Q. may differ to a similar degree in language and nonlanguage ability. Children in most classes require a range of reading materials which has a difficulty spread of four or five years. One cannot assume that in a typical class the pupils have made anything like the same personality development. There will be some pupils who are happy, secure, successful and well-adjusted, but there will also be those who are shy and withdrawing. There will be those who are aggressive, those who display anti-social tendencies or nervous symptoms which are evidences of conflicts or unsatisfied desires. Variation in ability and experiential background for science will be considerable. The so-called grade then is just a group of pupils who are designated by a number which indicates they belong to the same group and generally sit in the same room. At this point homogeneity ceases.

Differences of Children in Any Group

It is not uncommon among good teachers to incorporate the log of an experience unit in a more comprehensive record of the learning experience they refer to as a resource unit. In order that this resource unit may be more useful to them and to other

teachers who may wish to refer to it, it is usually customary to include a description of the group which participated in the work of the unit. Two such descriptions of actual classroom groups are included here as a real life illustration of the wide diversity one finds in any classroom and among classrooms. The following description is of a kindergarten group. Except for the large number of children involved, the group would be typical of classes in the lower primary school.

Description of the Group

> The Kindergarten at Randolph School is divided into a morning and an afternoon group, with 46 children attending in the mornings, and 43 in the afternoon group. At the beginning of the year before school opened, the parents of the incoming group were asked whether or not their children took afternoon naps. If they did, or if there was some other special reason, the children were placed in the morning group. This division resulted, although unintentional, in most of the more advanced children coming in the morning group.
>
> This year was a transitional year as far as age laws were concerned for entrance into a kindergarten. Previously, children have been allowed to start school if their birthdays came before January 1st. The law has been changed, so that from this next year on they will be allowed to come if they are 5 before the 15th of October.
>
> So, this group has a great age variance with a range from 4 years 9 months to 5 years 10 months. There is a correspondingly great variability in their physical maturation.
>
> In the fall an I.Q. test was given, so that if there were any children who were quite young who were also low in mental ability, they could be asked to wait a year before entering. The range of scores on this test was very great—from 83 to 146.
>
> At the beginning of the year it was also evident that the attention span of the children varied. Some children, particularly those with older brothers and sisters, were capable of maintaining an active interest and participation in discussions, while there were others whose attention wandered at the slightest provocation. Two of the children are still exceptionally nervous; they have difficulty in sitting still, resting, and keeping interested in one activity for any length of time.
>
> In the morning group there is one boy who transferred into this district about Christmas time, who caused and still causes a

need for special adjustment. He has a harelip, cleft palate, and a curvature of the spine. This latter defect necessitates a cast. The children were prepared for his entrance but there was still an adjustment to be made. The boy is emotionally unstable, for obvious reasons, which creates another problem.

Another special problem is created by a boy who could not seem to adjust to the school situation in which there are many boys and girls. He is retarded mentally, and needs to have instructions repeated several times. He does enjoy working with his hands, doing construction work, and obtains quite good results.

There is another child who has a very different problem. This girl is quite outstanding in all of her work. She has learned to read at home, matches tones well, uses originality in her art work, and obtains quite good results in her work. She, however, is emotionally unstable. She entered kindergarten last year and was withdrawn because of her apparent inability to adjust to the situation, noticeable by her frequent crying spells. This year, she seemed to have made a good adjustment; in fact, she was a good deal ahead of the majority of the children. However, the director reproved her for her continual visiting about three months after school began. The child is very sensitive, evidently, for she complained to her mother after this incident, that she did not feel well. For several days, she made the same remark at noon, just before she was to come to school. Her mother decided that she was not really ill, so brought her to school. The child complained that she was sick, and began crying. She was instructed to hang up her wraps and was given a new activity, jacks—to divert her thoughts. She cried every now and then all afternoon, but remained at school. The same experience happened for several days to a lesser degree each time. She has ceased this expression, but is still oversensitive to constructive suggestions.

There are about 15 children in each group who are noticeably advanced beyond the rest in ability. There are only about three who do not respond to directions readily, but wait to follow the other children. There are four in the morning group and six in the afternoon group who do not have a good sense of rhythm. Most of the children with the exception of about four in each group, can match tones pretty well and follow the melody of a tune.

These children are very observant of small details. They are interested in their surroundings and anxious to learn about them. There are two boys who have an exceptionally keen sense of humor, particularly noticeable at storytime.

All of these children are able to take care of their physical needs, and do so whenever necessary. They have learned to coordinate their muscles, so as to skip and enjoy other rhythms of an active nature.

There are several outstanding children, who have obviously had a wealth of background experiences in their homes. They grasp the topic of conversation quickly, contribute many ideas, and think through the solutions of problems, such as, ways to build furniture for the playhouse, what to include in an invitation.

The children work and play well together. The boys at play time usually construct a large building of blocks, instead of each one making a separate structure. They are receptive to any suggestion to make their work better, whether from the teacher, or another child.

The children do not have definitely formed groups of friends, as yet. They choose the person nearest them for a game. There are no *isolates* all of the time, and usually, if there is an *isolate*, it is because of his choice.

The following is a description of a third-grade class in another community of considerably larger size.

Description of the Group

In the third-grade room there are twenty children, twelve boys and eight girls. These children come from homes that are financed by a meager income. Three of the children are Mexican, two are Negro, and fifteen are children of immigrants.

The I.Q.'s of these children range from 85 to 105. Most of the children are retarded in reading with grade placement average being 2.6.

The general impression of this group is that the children are friendly in manner. They cooperate whole-heartedly and show enthusiasm and delight with each new experience except reading. They work only at those things that they enjoy and their rate of work is slow. They have difficulty in understanding directions. Most of them show limited understanding of English, speak ungrammatically and some with poor enunciation since in their homes their native tongue is spoken almost exclusively.

Some of the children are well nourished; others are undernourished. Their hearing is normal, as tested by the Maico Audiometer. Five of the children have defective vision.

Their range of information about their community is limited. The class as a whole has a very limited vocabulary.

Most of their fathers are employed in the "work gang" of the nearby railroad.

Some of the children either do part time work or assist their mothers in the home since the families are quite large.

Three of the children have repeated first grade while the rest are of a slow third-grade level.

The children rarely go to movies or participate in organized recreation. Radios or newspapers are seldom found in these homes. Their wishes are simple and concrete. The children are warm and affectionate toward others of their own age, but are greatly lacking in a sense of security and parental affection. The Rorschach Test shows emotional disturbances and marked anxieties.

There is evidence of uneven mental functioning, some confusion in their concepts and a tendency to arrive at hasty but erroneous conclusions.

The data which follow are taken from the performance of a class selected at random from a number of sixth grades. The material appears on a Class Analysis Chart of the Metropolitan Achievement Tests. This was a typical class tested at the second month of the sixth grade. Only the sections of the Class Analysis Chart showing the chronological age, mental age, I.Q., grade equivalent, and science performance are reproduced here. The boldface numbers in the body of the chart represent individual pupils.

CLASS ANALYSIS CHART

Grade Equiv.	Science	I.Q. Scale	I.Q.	Age Scale	Chronological Age	Mental Age
above 9.0	**3, 5, 10, 12, 13**	above 130	**10**	above 16–0		**10**
9.0		130		16–0		
8.9		129		15–10		
8.8		128		15–8		
8.7		127		15–6		
8.6		126		15–4		
8.5		125		15–2		
8.4		124		15–0		
8.3		123	**5, 12**	14–10		

Grade Equiv.	Science	I.Q. Scale	I.Q.	Age Scale	Chrono-logical Age	Mental Age
8.2		122		14–8		
8.1		121		14–6	22	5
8.0		120		14–4		
7.9		119		14–2		
7.8	**11**	118		14–0		
7.7		117		13–10		**19**
7.6	**19**	116		13–8		
7.5		115	**13**	13–6		**12**
7.4		114		13–4		
7.3		113	**19**	13–2		
7.2		112		13–0	4	**13**
7.1	**21**	111		12–10		3
7.0		110	3	12–8		
6.9		109		12–6		
6.8		108		12–4		
6.7		107		12–2		
6.6		106		12–0	**8, 16, 19, 20**	1
6.5	**7, 14**	105	**1**	11–10	**17**	
6.4		104	**11, 18**	11–8	**21**	
6.3	**1, 17, 18**	103		11–6	**3, 9**	**11, 21**
6.2		102		11–4	**1, 2**	**18**
6.1	**16**	101		11–2	**5, 15**	
6.0		100		11–0	**11, 13**	
5.9	**4, 9**	99	**21**	10–10	**7, 10, 12, 14 18**	8
5.8		98	**7**	10–8	6	7
5.7		97		10–6		**4, 14, 17**
5.6		96		10–4		
5.5	**8**	95	**14**	10–2		**6, 15, 20**
5.4		94	6	10–0		2
5.3		93		9–10		9
5.2		92	**8, 15**	9–8		
5.1	**2, 6, 22**	91		9–6		
5.0		90	**17**	9–4		**22**

Grade Equiv.	Science	I.Q. Scale	I.Q.	Age Scale	Chrono-logical Age	Mental Age
4.9		89	**2**	9–2		
4.8		88		9–0		
4.7		87	**9**	8–10		**16**
4.6		86	**20**	8–8		
4.5		85		8–6		
4.4		84		8–4		
4.3		83	**4**	8–2		
4.2		82		8–0		
4.1	**15**	81		7–10		
4.0		80		7–8		
3.9		79		7–6		
3.8	**20**	78		7–4		
3.7		77		7–2		
3.6		76		7–0		
below 3.6		below 76	**16, 22**	below 7–0		
No. pupils	22	No. Pupils	22	No. Pupils	22	22
Median	6.3	Median	96.5	Median	11–4	10–9

These data are presented to indicate quite clearly the variability one may expect in the capability and achievement in science among elementary-school children. You will notice, in this so-called typical class, pupil **20** was at the 3.8 grade level. Contrastingly, five pupils were above the grade level of 9.0, with very little clustering of any number of pupils at any one spot in between these extremes. After only a brief glance at these data it is quite evident that instruction must be on an individual and small group basis and the work of the class organized on the basis of flexible groupings.

The foregoing data support an oft quoted statement of which teachers must be acutely aware. That is, "that no two groups of children or no two children within a group are alike." They are unique in terms of physical inheritance, learning rate, environment, experiences and all the things that have happened to them. The implications of this knowledge for the teaching of science is simply this: Because children are different we cannot expect to teach them all the same thing at the same time in the same way.

Specific Suggestions for Planning

The teacher naturally asks, "If I must teach the children differently, what specific suggestions do you have to make which will help me create the desirable learning environment in my classroom?"

The first specific suggestion is that you provide a wide variety of experiences for the children. The children should have an opportunity to learn the principles and generalizations of science in methods other than reading about them or through appeal to the authority of the teacher. The following kinds of activities provide suitable learning experiences.

1. Reading books, magazines, newspapers, pamphlets, school papers
2. Writing lists of objects, charts, notebooks of science, reports, records of experiments
3. Making charts of many kinds, oral reports, interesting collections
4. Setting up aquariums, terrariums, experiments
5. Drawing scenes and diagrams and other pictorial illustrations
6. Taking trips for purposes of making observations
7. Interviewing people who know
8. Taking part in discussion periods and school programs
9. Setting up exhibits and arranging bulletin boards
10. Choosing a secret place for year-round observations
11. Constructing a bird bath, bird feeding tray, bird houses
12. Making surveys
13. Performing experiments
14. Participating in the making of plans
15. Keeping records of many kinds
16. Making dioramas and other special illustrations.

This list is not exhaustive, but it does provide possibility for observation, experimentation, excursions, use of audio-visual aids, reading, and the sharing of personal experiences.

It is the teacher's job to find out which of the above approaches holds the most meaning for the individual children in a classroom. Each child comes to school with a medium of learning which seems most profitable to him. Teachers should

encourage him to continue learning through that medium if he is enjoying success with it and build on this foundation by demonstrating to him many other profitable ways to learn. They will find some children grasp complex ideas more readily than others. Some of the children may get a great amount of good from reading about science, while others will get practically nothing from this activity. On the other hand, there may be a number of "doers" in the class who will excel when the learning takes on performance aspects.

The second specific suggestion for the teacher is, after determining the experiential background of the individual children in the room and providing many media for learning, set out deliberately to fill the gaps in the experiences of individual children through school experiences. Each individual brings to a learning experience his own pattern for learning and the meaning he gets in the new situation is always in terms of his past experiences. For example, there will be a wide variation in the readiness for science among those children having modern conveniences in their homes and those that do not have them. Some parents will provide their children such things as the service "Things of Science" which heightens their interest and increases their knowledge of science in out-of-school experiences. The observant teacher will provide sufficient experience to make the generalizations and facts of science meaningful.

Classroom library books, exhibits, pictures, experiments and excursions can all be used to open up new fields of study for children. Children who have only been interested in nature study should do something about electricity or some aspect of physical science. A teacher recognizing the differences in children expects them to respond to science in different ways. She recognizes their special individual interests and provides them opportunities to pursue these interests. In a class studying the universe it is quite probable that one child may have an intense interest in the sun or other feature of the universe and wish to study it thoroughly and later share the results with the entire group. It is essential that teachers provide children opportunities to do research in these areas of interest, to do experiments and to share the results of their work with the group.

At this point, you may say, "But I can't do all of that and follow the course of study. What can I do?" Most courses of study in science, as in other subjects, are merely suggestive, a way to help the teacher maintain balance in her program, giving some attention to various areas such as the universe, living things, physical forces and man's attempt to control his environment. It is impossible, however, for a course of study to take into account specific needs and interests of a particular child or group of children, nor can it give continuing consideration to current events of significance and interest. Teachers generally have plenty of opportunity to exercise initiative and ingenuity within the suggestive framework of curriculum guides and courses of study.

One might justifiably contend at this point that in a typical school where classes may be as large as 35 it is impossible for the teacher to be a tutor to each individual child. It becomes necessary to have some kind of organization within the group. Children like a degree of organization and will welcome the right kind. Learning activities are generally most profitably organized in some sort of a unit form. The pattern of a unit may be based on a specific purpose such as producing a play, making a survey of the community, publishing a newspaper, or giving a party for parents. The units may also be organized around centers of interest such as aviation, peace plans, China, pets. They may also be organized on a problem basis. For example, "How can we select our food from the luncheon menu more wisely?" It is, of course, quite possible that these and other units will appear in combination. The characteristics of different unit organizations are not mutually exclusive.

Organizing for Broad Units of Study

The unit of work or group enterprise may consist of a group of related activities directed toward the solution of a common problem. This group objective and the experiences which are planned to achieve it must be meaningful and of real concern for the children. In the initial planning period the teacher and the children will talk freely about the kinds of experiences they think would be valuable in studying and developing the unit of

Denver Public Schools

After initial curiosity is aroused, the children sit around with their teacher and plan their activities. Even on an early level, the boys and girls can decide what questions they would like to have answered and what activities to engage in to find the answers to those questions which they will have dictated to the teacher.

work. It will be the responsibility of the teacher to guide the class in exploring different ways of approaching the unit problem. She will suggest new experiences to supplement those chosen by the pupils. The close of the planning period should see the goal clearly defined and a series of steps outlined which will enable the group to solve the problem. After this is done a daily planning period will be concerned with specific problems and the evaluation of progress. In this plan is the key to the most acceptable type of grouping, a grouping which takes full account of what we know of child growth and development. It is sometimes referred to as grouping through cooperative planning.

Children may, for example, be studying a broad unit of work called *How Food Patterns Have Changed Because of Refrigeration and Food Preservation.* Within this broad unit there will be specific problems, such as: Why do we eat? What is enough to eat? How can we learn to choose enough to eat? Groups of children may be assigned to work on specific problems on the basis of their interests, abilities, needs, experiences, facility with materials or a combination of any of these. Within these specific problems assigned to small groups, there is a variety of activities which make it possible to meet the needs of the individual within the small group. Some of the experiences possible in answering the questions just mentioned, why do we eat? what is enough to eat?, are:

1. Read about these foods and what they do for our bodies.
2. Test for some food elements, such as fats, starches, sugars, protein.
3. Keep a record of the food one eats during one school week. Check this against the basic seven foods to determine which of the seven foods he is eating and which he is not eating.
4. Conduct an experiment with white rats, giving them different diets for a period of four to six weeks and observing the results of a proper diet and improper one.

Even this brief list of activities indicates the possibility for assigning work profitably on a small group and individual basis. There will, of course, be occasions for the whole group to work together and many occasions for sharing among the different groups of the class. Certainly, all of these groups must be "fluid." A child may be in many different groups during the day depending upon the types of activities in which the class is engaging. Grouping must be flexible in order that the demands of the immediate situation may be met.

A daily schedule to facilitate the kind of instruction just described must have greater flexibility than the usual school schedule and utilize large blocks of time. In a six-hour elementary-school day two $1\frac{1}{2}$-hour blocks of time should probably be devoted to study centered around units or large topics. One block of this time should deal with the solution of problems or

projects in health, community life and cultural education, international relations, government, economics, human relationships or any other important problems facing society which may be appropriately dealt with by children. These units would be selected on the basis of teacher-pupil planning within the frame of reference of curriculum guides. A variety of learning experiences should be provided. The other $1\frac{1}{2}$-hour period should be devoted to educative experiences in science, such as the care and observation of animals and plants and experimentation with simple machines and chemicals. This work should be designed to develop scientific attitudes and scientific methods of working, as well as to help the child understand himself and his environment and the interrelation of the two. The two blocks of time may be combined. Three additional one-hour periods should be devoted to maintenance of skills, music, free-reading, literature, auditorium activities, and to recreational and health activities. The blocks of time in such a schedule could be interchanged, could be combined, or, on a particular day, one or more of them could be omitted if the activity of a certain block of time was going well and it did not seem advisable to discontinue it at the end of the period.

Specialists in the field of Elementary Education are at present convinced that the best work is done in a self-contained classroom. It is not advocated that the administration provide specialized science rooms for elementary-school instruction. Every elementary-school classroom should have a heat outlet, a water outlet, science corner and provisions for keeping plants and animals. More detailed suggestions for equipping a classroom will be given in Chapter 9.

Understanding the Community

Communities in which teachers are located vary greatly. The community in which the school is located will be one of the most important resources for learning in science. It is important that the teacher know the community and utilize it to the best advantage. The following contrasting community descriptions show that significant science experiences, both potential and actual, will vary greatly from community to community.

Community No. 1

This community is located in a deteriorating area of one of our cities of 500,000 inhabitants. The conspicuous characteristics of this section are the deterioration of the structures and habitations which are occupied by these impoverished people. Their homes are not permanent for the most part, and the population is continually shifting. In this area, they do not conform to middle-class standards of respectability and morality. There is an unusually high rate of delinquency among the children. A minority of the families have religious backgrounds, while the majority use their Sundays as just another day of the week. Their social life revolves, as a rule, around the family in the neighborhood. There is a very high percentage of foreign people that occupy this section. This community is in the old industrialized section of the metropolis. The climate is comparable to that of Chicago—hot summers and severe winters. Most of the men are employed by the railroad or industries, while many of the mothers also work in nearby factories. Thus, the people do not have much ambition in improving their home surroundings or standards of living. Their leisure time, if any, is spent in visiting and carousing. These people have access to a very plain recreational hall. Two churches are located in this area, one Protestant and one Catholic, and they provide recreational facilities on a small scale. These are rejected by almost the entire population. In this heavily congested area, there appears a great amount of traffic in the forms of trucks, street cars, buses, and automobiles. Few of these families have telephones or modern conveniences, such as garbage disposal and adequate toilet facilities, to suit the needs of each family. The death rate in this area is high because of the unsanitary conditions, which attract many and sundry diseases. The birth rate is also high.

Community No. 2

It is a community in which there are many young families. Consequently, the school is overcrowded at the present time. The majority of the residents are home-owners. Many of the families are small-business owners, although there are a few fathers who are university students and university professors. These families are financially able to give their children all of the necessities and many additional privileges. They are not, however, overprivileged to the point that they are spoiled. This community is interested in education and the school. About half of the parents have had some higher education, many of

them having their college degrees. The Parent Teachers Association is very active in this district. The fathers, as well as the mothers, are interested in the education of their children and serve voluntarily on various committees organized by the P.T.A. The community has, for the most part, been built up during the last 15 years. It is primarily a residential area, with only one industry located within its boundaries. As a result of a questionnaire that was sent home for parents to fill out, we found that most of the children have had opportunities to go on vacation trips and to visit the zoo and places of local interest and importance. And on the kindergarten level, at least, the parents read to the children and discuss their school interests with them. Many of the children have had experiences which are valuable to share with other children. For instance, two of the fathers from the kindergarten group own their planes, and, thus, the children have a chance for firsthand observation. Those whose fathers are professors can offer information on the subject matter which the father teaches. The mothers of the pre-school-age children have organized a study club, apart from school supervision; but they depend upon the school for much of their guidance. The children of this area have access to several playgrounds, and there is also a tract of land which has not been developed as yet, which makes a good spot for nature-study excursions, since it is close to the school building. Library books are offered through the school system. Children may check them out from school. Music lessons and instrumental work are also offered. A Physical Education program has been established in this last year, with a special instructor in charge. The traffic in this area is not heavy, with one exception, and there is a signal light for it; so the safety problem in this community is not too difficult.

It is imperative that a teacher study her community, for it is in the community setting that science can be made truly meaningful. When boys and girls, no matter how much else they know about science, can relate at least a part of what they know to themselves and the life in their community, they are on their way to understanding all aspects of science. Probably no one is well enough acquainted with his community to know just how much of science is encompassed by it. Although the teacher will want to make a preliminary survey of her community, it is highly desirable that she also make this a class activity, for the children, as well as the teacher, need to know their community better.

Initiating a Community Survey

Stimulation for a community survey can come from the fact that a teacher is new in the community, or it may come because of a letter from another class requesting information about the community which has to be answered. Surveys of different aspects of the community may go on simultaneously if committees are doing the work, but reports should be shared with the whole class group. Exhibits and collections should be made, newspaper articles and books about the community should be collected, pictures should be drawn or clipped or gathered from any source possible, and, of course, many interviews and trips will be a necessity. Many parents will like to help make the survey if they can be brought together to hear pupils tell about what is being done and proposed. Be sure to let the boys and girls help decide upon what is to be included in their survey. The more of the things suggested that they do in surveying their own community, the greater understanding they will have of it and the more they will know of science as it relates to all aspects of community life.

Determining Purposes or Goals

It is necessary that there be a formulation of a clear statement of purposes in terms of child behavior. A tentative statement of purposes should be prepared in advance by the teacher. As a result of teacher-pupil planning, this initial list would be revised into a statement of purposes which are acceptable to both the children and the teacher, and which they both feel are their own.

Failure in many teaching situations to do anything of significance can be traced directly to the failure to formulate purposes. Purposeful planning is one of the principal ways of avoiding one of the common pitfalls of teaching through activity for activity's sake. Teachers should take time frequently to address to themselves the question "Why?". Purposes inhere only in people; so "Purposes for whom?" is an important question. Teachers can take considerable satisfaction in the knowledge that pupils have a great deal of respect for purposes.

A teacher in a mid-western city, anticipating study of a unit of science on weather in the third grade, established the following purposes for the unit:

1. To help pupils to understand how activities and work are affected by weather
2. To give pupils some knowledge of the composition and importance of the atmosphere
3. To give pupils some knowledge of what brings about changes in the weather
4. To develop skill in reading weather charts, thermometers, and barometers
5. To give pupils an opportunity to observe for themselves, to think out problems, and to encourage critical thinking
6. To develop an awareness of available community resources.

As the unit was initiated with children, the possible outcomes were discussed jointly by the group. The purposes which the children could accept as their own and the ones which became, finally, the expressed purposes were as follows:

1. To find out how weather affects people
2. To find out why we have different kinds of weather
3. To find out why we have different seasons
4. To find out what wind is
5. To find out what air, snow, rain, clouds, and fog are, and how they are caused
6. To find out how the wind helps us
7. To find out how the winds are named
8. To find out how many different uses of water can be discovered
9. To find out why the sun is important to us
10. To find out how the weather affects travel.

Although this list of pupil objectives seems to be in adult terminology, and not quite child-like, there is evident quite a different approach from that expressed in the initial teacher objectives.

Getting Started

There is a natural readiness for science among most children. The child's naturally inquiring mind needs assistance and confidence in understanding himself in relation to his environment. He needs a deep and intimate acquaintanceship with his surroundings, and from his experience in these surroundings, he needs to develop a set of generalizations and principles which will help him to be a better social being. Teachers have no problem, then, of creating a desire for science or of developing a broad science program. For most teachers, it is primarily a problem of: "How do we get started?" There are a number of ways of initiating science activity. It may be done through incidental happenings, a science fair, a movie, a discussion period, the daily news, science corner, dramatizations, or a collection; by following pupils' lead questions; by setting the stage to stimulate a desire to find out; and by cooperative planning which results in the selection of an area to be approached scientifically with which the pupils may start. One unit may be initiated by one method and another unit by one of the other methods described above.

Pupil Experiences for Development of Important Concepts

In preliminary planning, it is not sufficient for the teacher to say, "Well, we'll study about air." Of course, it is in the cooperative planning period with the pupils that the problems to be solved concerning air will be defined. However, the teacher should have in mind some of the understandings and knowledges concerning air that she hopes to have the children obtain. She also should plan many activities in which the pupils will have an opportunity to develop these understandings and knowledges. For very young children, the teacher may wish to convey the concept that air is everywhere. An experience she may have the children engage in which will convey this idea is to put some soil into a glass, pour some water over it, and see what happens. It should not be expected that generalizations will be attained on the basis of one experience. They will develop from many experiences in a variety of situations. This one activity is, of course, only illustrative. For a child of eight or nine, the teacher

may decide that the concept that should be obtained is that air has weight. An experience she may provide the children is to weigh a deflated basketball, fill it, and weigh it again. "What difference do you find in the weights?" "How do you account for the increased weight in the inflated ball?"

The first concept—that air is everywhere—may be tested in a functional situation by asking the children to explain why fish can live in water, or why we see many earthworms on the sidewalks or on the top of the ground after a rain.

Parallel to this planning of concepts and experiences to be used in development of them, there should be considerable study of content on the part of the teacher. In any case, there should be developed a good bibliography of books for the teacher and also a bibliography of books for the children, of movies, filmstrips, and all other resources for learning available in the community.

Evaluation

An important part of the teacher's planning and organizing educative experiences in science is to make some provision for evaluation of the work of the group. By evaluation is meant the appraisal of the effectiveness of educative experiences in attaining predetermined purposes. This problem is discussed in detail in the last chapter of the book, so no further attention will be given to it at this time.

Records of Plans

The need for the teacher to do considerable pre-planning and organizing, as well as cooperative planning with the pupils, has been expressly stated and frequently implied in this chapter. Suggestions for organization and management of the pupils in the classroom, as well as for careful planning of units of work, experience or subject-matter, have been included. The necessity for an informal atmosphere in the classroom, where the teacher assumes the attitude of a friendly helper in planning and directing activities, has been indicated. The importance of freedom of movement to facilitate science instruction in the classroom cannot be overemphasized. Science areas should include

numerous items to stimulate group and individual experimentations. Magnets, different kinds of objects, magnifying glass, specimens of plants, and many other items create opportunities for applying scientific facts. There should be facilities for growing plants or caring for pets, a science corner, charts for recording observations, and any other physical facilities which will assist in better teaching of science. The preliminary planning of the teacher should be informal and flexible. This planning should become definite after cooperative work with the pupils. As the development of the work in solving the problem progresses, it is advisable for the teacher to maintain a log of the experiences utilized. When the work is completed, this log of the experiences should be incorporated into a permanent record of the work. This kind of record is sometimes referred to as a resource unit. Resource units are often exchanged among groups of teachers so that each may profit from the experiences of the others.

The following headings are suggested as desirable sections of a resource unit: Description of the Group; Description of the Community; Statement of the Problem; Purposes for the Teacher; Purposes for Children; Initiation of the Unit with the Pupils; Unit Development through Pupil Experiences; Important Concepts and Information Used; Culmination or Summary Activities; Evaluation of the Unit; Bibliography.

The following illustrative resource unit was compiled by a student teacher after working a semester in a public school. She incorporated her log of classroom experiences with her preplanning in making the record. The unit shows how a helpful record and guide may be developed by even an inexperienced teacher.

Unit of Science on Weather

Description of the Class

> Ten boys and sixteen girls comprise this class of twenty-six pupils. The chronological ages range from 7 years 7 months to 9 years 4 months. The range in I.Q. is 70-110. Four of the children are repeating the grade. Two of the girls are new members of the class. They are in the slow group of readers and are not being accepted very well by the rest of this third-grade class.

Description of the Community

The children come from a community which covers a large area in which are found many factories and plants. The parents are employed in the following places of business: a watch factory, a motor scooter company, a planing mill, and a concrete block plant. These occupations indicate upper, lower and middle social classes. The most secure parents probably are the civil service post office employee and the city firemen.

In this community can also be found many churches, stores (including an upholsterer), libraries (branches), the State Fair Grounds, and the State University's Agricultural College. This area is very near the railroad tracks. The homes are not modern, but most of them appear to be neat and many are being painted.

Statement of the Problem

Our problem in relation to weather is that of determining a program of activities through which the children will gain a greater understanding of what weather is and how it affects them from day to day.

Teacher Objectives—to

- **a.** Help pupils to understand how our activities and work are affected by the weather.
- **b.** Give pupils some knowledge of the composition and importance of the atmosphere.
- **c.** Give them some knowledge of what brings about changes in the weather.
- **d.** Develop skill in reading weather charts, thermometers, and barometers.
- **e.** Give pupils opportunities to observe for themselves, to think out problems, and to encourage critical thinking.
- **f.** Develop an awareness of available community resources.

Pupil Objectives—to find out

- **a.** How weather affects people.
- **b.** Why we have different kinds of weather.
- **c.** Why we have different seasons.
- **d.** What wind is.
- **e.** What air, snow, rain, clouds, and fog are.
- **f.** How the wind helps us.
- **g.** How the winds are named.
- **h.** How many uses of water can be discovered.
- **i.** Why the sun is important to us.
- **j.** How the weather affects travel.

Initiating the Unit with the Pupils

One rainy day Mary noticed the postman coming up the walk with the mail for the principal. She remarked, "The postman is getting awfully wet delivering his mail."

This observation stimulated a great deal of conversation. It introduced the idea that some activities must go on in spite of the weather. The teacher told the children the slogan of the United States Post Office Department: "Not snow, nor rain, nor heat, nor gloom of night stays these couriers from the swift completion of their appointed rounds."

Other children said that people have to make changes in their ways of living or in their plans because of the weather. During further conversation about the weather, the children also suggested that picnics might have to be postponed or cancelled because of wind or rain, that a rainy day is a good day for a taxi driver because so many people want to ride in taxis to keep out of the rain, and that a rainy day is a bad day for a delivery man or a bus driver or a street car conductor. One of the children, whose uncle is a farmer, suggested that wind and rain can be both good and bad for people who live in the country as well as for the people who live in town.

The children decided they would like to know why we have rain, sunshine, wind, hot days, cold days, and many other aspects of what we call weather.

Unit Development through Pupil Experiences

The emphasis throughout this unit is placed on firsthand observation by the pupils and upon their participation in activities selected and designed to result in significant and desirable outcomes. These experiences are, of course, to be supplemented with research-reading by the pupils, and appropriate materials are to be provided.

Pupil Experiences	*Concepts*
1. Keep a weather calendar. Use such symbols as an open umbrella for rainy days, a closed one for cloudy days, a kite for windy days and a sun for sunny days. What happens to the weather from day to day?	a. Weather may change from day to day.
2. Place a thermometer in the shade for a few minutes.	a. Heat makes the mercury in a thermometer go up.

Mark the place to which the top of the liquid (mercury) column sinks. Then move the thermometer into the sunlight. What happens to the column of mercury?

Place some ice in the sunlight and an equal amount in the shade. Observe from time to time what happens to each piece.

b. Heat comes from the sun.
c. Heat melts ice.
d. Ice melts faster in the sun than in the shade.

3. Fill two pans of the same size and shape with water. Place one near and one away from the stove or radiator. Measure the water in each pan from day to day. Which loses water more rapidly?

a. Heat makes water evaporate faster.

4. Cut a piece of cloth into two pieces of equal size. Wet both pieces and squeeze out as much water as you can. Leave one in a crumpled mass so that very little air will get to some parts of it. Spread the other out. Observe which dries first.

a. Water evaporates faster when the air can get to it freely.

5. Moisten two equal areas of the blackboard. Fan one with a paper. Which dries first? Why?

a. Water evaporates faster when air moves past it.

6. Place two or three cups of water in a teakettle and heat to boiling. This will cause the water to evaporate very fast and form water vapor. Notice that the water vapor which leaves the spout cannot be seen until it is two or three inches from the spout. Then you can see it as a cloud made up of fine drops of water. Take a cold pan and hold it in the cloud. What happens?

a. Water which has evaporated is called water vapor.
b. Water vapor cannot be seen.
c. When water vapor is cooled, it changes back into water.
d. A cloud is made up of tiny drops of water.
e. Water vapor becomes a cloud when it is so cool that drops of water are formed.

Now hold a warm pan in the cloud. What happens? Remove the teakettle from the fire and cautiously look into it. Observe that much of the water is gone. What has happened to it?

7. Learn to read a thermometer. Keep a record of daily thermometer readings in the morning, at noon, and in the evening.

   a. The thermometer tells us what the temperature is.
   b. The temperature changes during the day.

8. Dry the outside of a tin can or of a drinking glass. Put some water into the can. Observe the outside of the can or glass to see if there is a film of water on it. If there is not, drop small pieces of ice into the water and stir. Continue until a film of water appears on the outside of the can. Where does the film of water come from?

   Repeat this activity each day for several days. As soon as the film of water appears on the outside of the can, take the temperature of the water. Is it the same each day? Why? Dew forms on grass just as drops of water do on the sides of the can.

   a. There is water vapor in the air all of the time.
   b. Water vapor in the air changes to water when it is cooled.
   c. There is more water vapor in the air on some days than others.
   d. Dew forms on grass when the water vapor near the grass cools enough to cause drops of water to form.

9. Blow a little air into a toy balloon and tie the neck securely. First place the balloon near a radiator or stove. Does the balloon get bigger or smaller? Now place it in a cool place. Does it get bigger or smaller?

   a. Air expands when it is heated and fills more space.
   b. Air contracts or fills less space when cooled.

10. Hold a piece of smoldering wood or paper above a stove or radiator, then at one side

   a. Heated air rises.

and near the bottom of the stove or radiator. In what direction does the smoke travel? Why?

11. Hold a piece of cloth tightly over the end of the hose of a bicycle pump. Work the pump quickly to compress the air within the barrel. Feel the barrel in a little while. What do you notice? Why?

    Let the air out of a valve of a bicycle tire. Feel the temperature of the air as it escapes. How does it feel? Why?

    a. Air is warmed when it is compressed.
    b. Air is cooled as it expands.

This list of eleven pupil experiences and their accompanying concepts is suggestive of the type of activity through which children in the third grade can learn more about weather. It is not intended to be a complete list, nor is it supposed that any particular classroom situation would be such that each item could be used without modification.

Important Concepts and Information Used

The following outline is intended to suggest a general direction for our study of weather:

A. Class discussion on how weather affects people
   1. Farmers, other workers, children
   2. Travelers on buses, automobiles, trains, airplanes
   3. Homes we live in and food we eat
   4. Planning trips, picnics, sports
   5. Kinds of clothes we wear

B. Factors composing weather
   1. Air
   2. Wind
   3. Moisture
   4. Sun

C. How changes of weather are brought about
   1. Wind
      a. Force of wind varies
      b. Temperature of wind varies
      c. Direction of wind varies

2. Moisture
   a. Water goes into air
   b. When air is cooled, water forms into drops (rain, fog, snow, sleet)
3. Sun
   a. How it warms the earth
   b. Effect on growing plants
   c. How it affects our health

D. Air
1. What is air?
2. Where is it found?
3. Can we see air (is it visible)?

E. Wind
1. What is wind?
2. Kinds of wind
   a. Hurricane, cyclone, tornado, gales
   b. Breeze, gusts
3. Names of winds: North; West; East; South
4. Work of the wind
   a. Moves the clouds; helps change weather conditions
   b. Dries streets, walks, roads, clothes
   c. Melts snow
   d. Turns windmills (pumps water)

F. Rain and clouds
1. What makes clouds? (Ex.: Water goes into air from rivers, lakes and ground. This water is called vapor. Vapor cools and forms tiny drops. Drops of moisture, so light they float in air, form clouds.)
2. What makes it rain? (Ex.: Rain clouds get cooler; so tiny drops run together to form big drops. Big drops are too heavy to float in air; so they fall to the earth.)
3. Fog
   a. What it is
   b. Where it is
   c. What it looks like
4. Hail or sleet (rain drops turned into ice)
5. Snow (water vapor in clouds forms snow)
6. How rain and clouds can help us
   a. Rain washes the earth and makes it soft
   b. Rain cools the air
   c. Clouds shade us from the sun
7. How rain and clouds can hurt us
   a. Too much rain causes floods
   b. Fog is dangerous to travelers

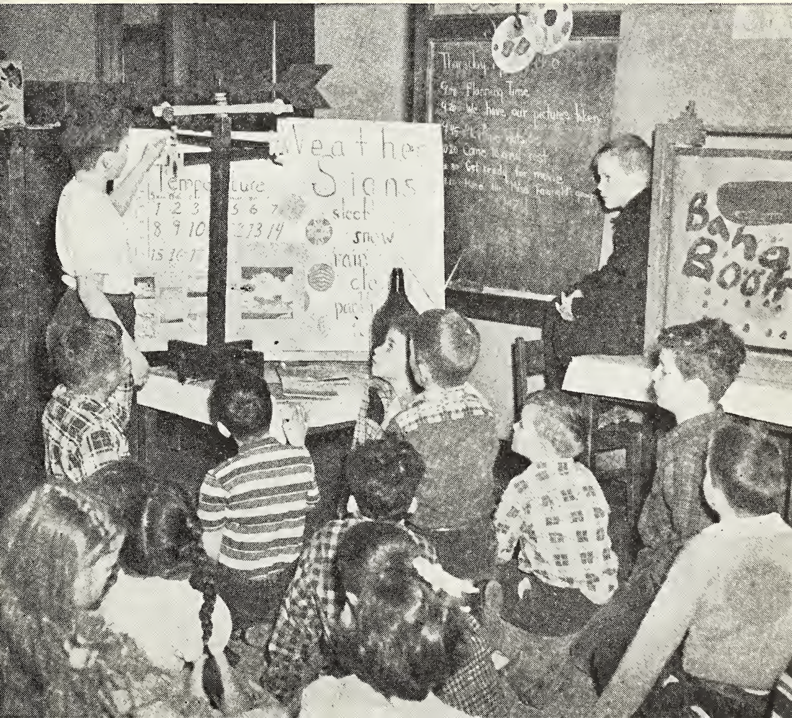
G. Sun
   1. Uses of the sun
      a. Gives us light and heat
      b. Warms land and air
      c. Helps living things grow
   2. Sun and weather
      a. Seasons
      b. Evaporation (water cycle)

Culminating Activity

The children will have made many things, collected pictures and weather maps, and learned many skills. At the close of their study, they may want to have "Open House" to exhibit these things. Also, a skit or play may have been written in which they can demonstrate some of the skills that they have learned both in speaking and working with others and handling materials in the performance of simple experiments. The other classes in the school, or their parents, may be invited.

Children from another class are invited to hear what one class learned about weather.

Glencoe, Illinois



Evaluating Activities

The culminating activity provides an excellent opportunity for evaluation. From observation one would think that they have a greater understanding of the effect that weather has on our living. In inclement weather, when the children cannot go outdoors for recess, they are more cheerful and resourceful in thinking of activities to do during that time, such as recording the readings of the barometer and thermometer and making entries on our weather calendar. They are more conscious of the changes in the weather and often make their own predictions as to what the drop in pressure or temperature might mean as well as the differences in the sky with its various kinds of clouds. Their cheerfulness during inconveniences caused by "poor" weather has apparently developed from their understanding that this weather is very important to them indirectly (in the growth of the food they like so well) and in the greater comfort they experience afterwards. Some of the children derive much joy in keeping the rest of the children informed about news items concerning the effect of the weather on the community. They are more capable of attacking problems that may arise without the great amount of help that they formerly required. They still need help, of course, but they show that they are thinking, for their questions cannot be answered as simply as they quite often were before we worked on this unit. This last is very satisfying to observe. The children were given a teacher-made test to see if they had grasped the subject matter involved in the unit.

Bibliography

Books for Children

Andress and Goldberger, *The Health Parade* (Ginn and Co.) pp. 47–50. Emphasis on the importance of fresh air and what it does for us.

Andress, J. Mace and Others, *Growing Big and Strong* (Ginn and Co.) pp. 16–17; 182. How the universe uses air and water; essential to growth.

Beauchamp, Wilbur L., Blough, Glenn O. and Melrose, Mary, *Discovering Our World* (Scott Foresman, Book I). Good pictures of various weather conditions.

Beauchamp, Wilbur L. and Others, *Science Stories* (Scott Foresman, Book II). Presenting weather phases in an interesting manner.

Booth, Harold H., *Book of Modern Warplanes* (Garden City). Good pictures. What weather conditions mean to flying.

Craig, Gerald S. and Others, *Wide, Wide World* (Ginn and Co.). How weather affects climate, vegetation, living conditions. Good pictures.

Fenton, Carrol L. and M. A., *The Land We Live On* (Doubleday). Good for study of the importance of water to everyday living.

Floherty, J. J., *'Board the Airliner* (Doubleday). What one sees in the sky. How weather changes the pilot's plans.

Fraiser, George W., *The Seasons Pass* (Singer). Good study of the four seasons. How they are different and why. Good pictures.

Horn, Ernest and Others, *Making New Friends* (Ginn and Co.). "The Airplane Trip," pp. 191–207. Interesting little story of children taking an airplane trip, showing again the influence of weather on flying.

Horn, Ernest and Others, *More Adventures* (Ginn). "The Thermometer," pp. 163–169. Story of children learning to use the thermometer.

Huber, Miriam B. and Others, *Planes for Bob and Andy* (Macmillan). Good pictures. Interesting reading for children.

Lenski, Lois, *The Little Airplane* (Oxford). Good pictures.

Lent, Henry B., *Flight 17* (Macmillan).

Lent, Henry B., *Straight Down* (Macmillan).

Lent, Henry B., *Straight Up* (Macmillan).

Series dealing with flying. Interesting and have good pictures.

Melrose, Mary and Others, *My Land and Your Land* (Conservation Series, National Wild Life Federation, Inc., Washington, D. C.). Effect of weather on animals. What is done to help them protect themselves against weather; how nature protects them.

Pryor, Wm. C. and H. S., *Airplane Book* (Harcourt).

Shenton, Edward, *New Alphabet of Aviation* (Macrae-Smith).

Tousey, Sanford, *Airplane Andy* (Doubleday).

The last three are some additional books on airplanes and weather.

Books for Teacher

Arey, Charles K., *Science Experiences for Elementary School.* Many unique classroom experiments which can be successfully carried on.

Craig, Gerald S., *Science for the Elementary-School Teacher* (Ginn).

Air: pp. 213–218

Water: pp. 19–94; 212–220; 226–262

This book gives very helpful information for the teacher. It lists concepts to be learned and experiments suited to the various grade levels.

Craig, Gerald S., *Science in Childhood Education* (Bureau of Publications, Teachers College, Columbia University). Excellent in showing children's interests and adaptability to science experiences.

Croxton, Walter C., *Science in the Elementary School* (McGraw-Hill). Good concepts and practical experiments.

Suggested Activities for the Science Program in the Nebraska Elementary Schools (Nebraska Department of Public Instruction, Wayne O. Reed, State Supt., State Capitol, Lincoln). Very valuable for practical information dealing with concepts, experiments and objectives. Helpful in integrating with other subjects and grade levels.

Films

Airplane Trip
Robin Redbreast
Seed Dispersal
Works of Running Water
Gardening—advanced for grade but helpful for general idea
Roots of Plants
Play for the Snow—good for seasonal study

Films are produced by Encyclopedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Illinois.

Trips

Visit the local weather station.

Plans Become Real Experiences

Real experiences which children have are, of course, much more important than paper plans. The following description contrasts two teachers' success in making their plans function in the lives of children. Although these descriptions are quite different from planning records, you may be assured that Miss Horne did much pre-planning and cooperative group planning with children.

This is a conversation between John and Steve, two primary school boys who were waiting in the principal's office for some supplies.

"I sure hope I'll be in Miss Horne's room next year," said John.

"Miss Baker is lots prettier," said Steve.

"I know," said John, "but Miss Horne lets you do *real* things in her room."

The supervisor, who overheard the conversation, visited the classrooms of the two teachers who were under discussion. At a casual glance both rooms were attractive and livable. In Miss Baker's room there were gayly colored draperies at the windows and flowers blooming in pots on the window sills. Everything was spotlessly clean and in its proper place. The blackboards had just been washed, and chalk and erasers were placed at regular intervals ready for children to work at the board. Two bulletin boards were in the room. One had printed over it

"Our Best Work" and on it were thumb-tacked neat, correct papers of arithmetic problems, spelling papers, and samples of pupils' penmanship. The other bulletin board had two pictures carefully mounted on red construction paper, one of Washington, one of Lincoln. Around the top of the blackboard was a border of spring flowers cut from patterns, a tulip and a jonquil alternating.

Miss Horne's room was not as immaculately clean as Miss Baker's, but even a glimpse from the doorway made one feel it was a place where people worked and lived. The furnishings of the room were the same as those of Miss Baker's, but they were used and arranged differently. One bulletin board had on it six or eight pictures painted by the children with original stories accompanying them. The pictures and stories told about a trip the class had taken recently. Each one depicted an incident that appealed to the writer. One picture showed a flower garden, and the story which accompanied it told of a visit to the home of one of the pupils on the way back to school. Boys and girls were sitting in the garden drinking lemonade as they admired and discussed the flowers.

Another showed the whole class in the field. The story accompanying this was not factual, as most of them were, but was a product of the author's imagination.

The Little Hitchhiker

Two little hitchhikers were in the field. One said, "I'm tired of this field. I want to go out and see the world." Just then the third grade children from Cassidy School came to the field. They were looking for different kinds of seeds. The two little hitchhikers watched them. Then one said, "Now is your chance to see the world." The other one waited till Missie came by and then he hooked himself on to her sock. When the children started home the little hitchhiker waved goodbye to his friends. Soon the children were all back in school. Everybody was happy except Missie.

At the front of the room a frieze and some experience charts gave one a good idea of what the trip meant to the children from the standpoint of education and how much pleasure they had derived from it.

The first chart was:

What We Want to Do

Collect seeds
Learn the names
Classify seeds
Mount specimens
Draw pictures
Write stories
Make a map of the trip
Make a movie of the trip
Make a frieze of the trip
Have an exhibit of what we get

Beside this was a map of the route that was taken. It showed the location of the school, the streets that were traveled, the homes of classmates that were on the way, the stop lights and the final destination.

Another chart told of their plans for behavior on the trip.

Our Trip

We shall stay together.
We shall walk on the sidewalk.
We shall watch for cars when crossing the street.
We shall cross the streets with the green lights.

On a chart rack were hanging group stories telling things they had learned in connection with the trip, such as:

How Seeds Travel

The wind makes some seeds travel. Some seeds that travel with the wind have wings or parachutes. Some plants have pods that pop open and scatter the seeds. Some seeds are carried by animals. Squirrels carry nuts.

The first picture in a frieze showed pupils in the classroom when they were making plans for the trip. The second was of the children crossing the street at the corner. A chart told how they planned to behave as they walked through the streets.

A table at the back of the room had on it a magnifying glass, a magnet, a small electric stove and some jars.

Near the window was a terrarium and under it was a chart that told how it had been made.

The evidence of *real* work, as John called it, was all over the room. It is easy to understand why he preferred taking trips, making terrariums, and writing factual and original stories about his activities to writing compositions dictated by his teachers and drawing pictures suggested by the art teacher for every child in the room to draw.

In teaching science the teacher should encourage her pupils to do *real* things just as Miss Horne did. She can lead them to see how the knowledge of science has made our homes and our schools more comfortable, more convenient and more sanitary. Any teacher who is interested in developing in her pupils an appreciation for and an understanding of the world about them can find many avenues for this in the classroom and in the school environment.

Summary

Any teaching can be improved by careful planning. A part of good planning is giving thought about organization of the curriculum, about possible activities and materials that will be needed, about the pupils who make up the class or group, and about possible procedures. A few special features of planning have extra importance for the program of instruction in science. In no other area of the school curriculum is the use of the community of more importance than it is in the area of science. In science, as in other subjects, the curriculum may be set up in advance and organized logically and formally, but an approach to learning through stating purposes and activity on the part of children can be justified easily. In science, particularly, that approach is almost obligatory if real learning is to result.

Increase Your Understanding

1. Visit two elementary-school classrooms for children of the same level in years in school. Compare them for their evidence of efforts to stimulate learning in science.

2. Describe your community in some detail. Compare it with the two communities that are described on pages 106–107. What special problems in teaching science would your community present?

3. How would differences in level of ability in reading affect a program of instruction in science? Would it be possible for all children to use an adopted textbook? How?

4. Collect all the data you can for a group of ten or more children in the same school year. Analyze the data to show differences in children in a group. How are the pupils all alike? In what ways do groups of them seem, from the data, to be alike? Are there ways in which each member of the group differs from every other member of the group?

5. Develop a resource unit of science on a topic you select as appropriate for an age level.

Additional Readings

Burton, W. H., *The Guidance of Learning Activities*, D. Appleton-Century Co., 1944. pp. 244–263.

Caswell, Hollis L. and Forshay, Wellesley A., *Education in the Elementary School*, American Book Co., New York, 1950. pp. 138–146.

Lee, J. M. and Lee, D., *The Child and His Curriculum*, D. Appleton-Century Co., 1950. Chapter VII.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 60–73.

Chapter 6

Avenues for Science Instruction

In the preceding chapter, devoted to a discussion of general planning and organization for improved science teaching, it was indicated that much of this chapter would be devoted to helping the teacher get underway with science. Instruction in science in the elementary school may be approached through many avenues. All kinds of activities that are common to classrooms and school buildings and grounds can be enriched by calling upon the subject matter of science to help explain them. The program in science may be approached through a series of readers that have content in science, through books on science in classroom and school libraries, and through the textbook adopted for the planned course in science. Much science may be learned in connection with units of work and with other content subjects of study. Incidents of all kinds may lead into science. Avenues through which instruction in science may be approached are almost as numerous as the aspects of science itself.

Exploration of the School Building

Exploration of the school building and of activities in and around the building is an interesting avenue through which to approach a program of science. Here are some illustrations of how you may begin.

Explorations of the building and grounds of the school can be used for leads into science throughout the years in the elementary school. The explorations will serve many different purposes and be carried on at many different times, of course; but that they

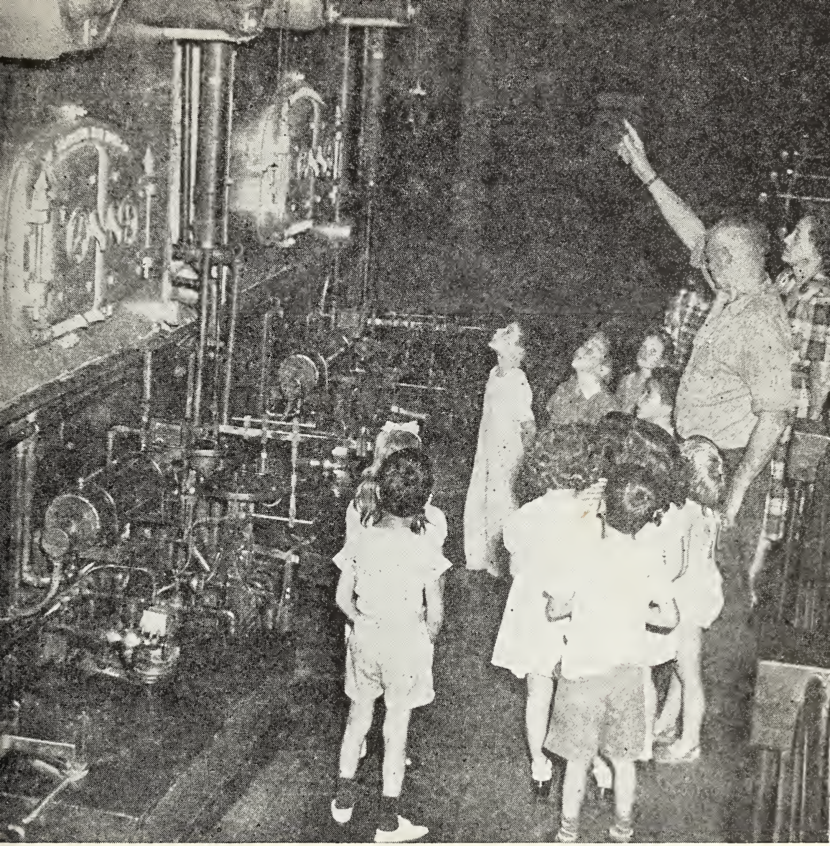
are avenues through which instruction in science may be approached will at once be clear to anyone who thinks about the matter. With definite concepts they hope to develop in mind, the teachers have many resources at hand that are too often ignored.

At the beginning of the school year, teachers become so engrossed in obtaining information for permanent records, requisitioning books and supplies, and other types of clerical work necessary to get the machinery of school going that they often overlook the most important thing from the standpoint of the pupils—their orientation. A sense of responsibility and a good attitude toward the school can be started by an orientation trip in the building. Many things the children see may stimulate an interest in science.

A trip to the boiler room to see the furnace and an introduction to the janitor will start an interest in how the building is heated. Pupils of the intermediate grades will be interested in how the heat reaches the rooms. Such questions as these may be asked: Why doesn't the heat burn the building as it goes to the rooms? What makes it rise? What temperature is correct for a classroom? What is correct for the home? Why is there a difference? How is the classroom ventilated? Why is fresh air needed? These, and many others, will arise if a group is given an opportunity for a free discussion. Good science work may grow out of this experience if children are given an opportunity to plan and use ways of discovering answers to their questions. As an outgrowth of this study, the following laws of science will be meaningful to the children. This obviously is not an exhaustive list.

1. Hot air rises.
2. Some substances are good conductors of heat.
3. Some substances are poor conductors of heat.
4. The human body gives off heat.
5. People exhale carbon dioxide.

The playground should be visited in order for the children to learn where they are to play, what shrubs and trees they are to protect, and how they are to use the playground apparatus. There may be things on the playground that they will want to learn more about at a later time, such as a stream, a flower bed, a pool, or an example of erosion.



Glencoe, Illinois

After kindergarten or first-grade children have visited the furnace room to get acquainted with their school, the teacher will find many leads into science from their questions.

A visit to the cafeteria before lunch time to show how it operates will make the lunch period easier for pupils and teachers. Later, the subject of nourishing food and the types of lunches that should be selected could be a study of many weeks, particularly if there are underprivileged children in the room. In many instances, however, this subject is as important to the children from good homes as it is to the less privileged ones. With the menu on the board, a daily discussion of a balanced

meal to be selected from the list is time well spent. In the intermediate school years, there are few subjects that appeal to children more than food. They are interested in what parts of plants we eat, why we eat the leaf of one and the root of another, what cooking does to the food, how foods are preserved and transported, and their value to us. Not only is it a subject that is brought to their minds three times a day, but it offers opportunities for experiences of various types, such as raising vegetables, cooking foods, and performing experiments.

Even if a class does not go into a detailed study of foods, there are certain facts pertaining to health that every child should learn in connection with his food habits. Even primary-school children can learn that the seven basic foods are: green and yellow vegetables; oranges, tomatoes, raw cabbage, grapefruit, and salad greens; potatoes and other vegetables and fruits; milk and milk products; meat, poultry, fish, or eggs; bread and cereals; butter. They can also learn how to select a well-balanced meal. Much usable material that is free or inexpensive can be secured for the study of food and food values. The illustrations are usually excellent, and the reading matter is often easy enough for the use of school children. Pupils can learn the importance of cleanliness in eating food. They should be given time to wash their hands before eating lunch.

Boys and girls of all ages like to cook. At school, they make butter, apple sauce, or cookies. Before undertaking the work of preparing and cooking food, they observe the methods used in their own lunchrooms. They learn what happens when one is careless about cleanliness in the kitchen. Their lunch period is a time when they put into practice some of the things they have learned. They chat leisurely as they eat a balanced meal carefully selected. They are acquiring the habit of partaking of meals in a healthful way.

The number of trips to take in the building would depend upon the size of the school. In the small school, one or two might be sufficient. In larger ones, better results could be obtained if the library, the cafeteria, the halls, the fire escapes, the gymnasium and the auditorium were visited on separate days. If this is carefully done, the children will adapt themselves to their new

environment quickly, and a feeling of belonging will take the place of homesickness and insecurity that they so often feel at this time. A pupil who has transferred from some other school could be introduced to the building by a classmate or a committee of one or two children.

With the concepts she wishes the children to develop in mind, the alert teacher will find many sources of science learnings and many ways to illustrate them in her own school and its immediate environment.

Discussions, group or individual stories, and original paintings and drawings of their experiences in or about the building will give the children satisfaction, lead into aspects of science, and fix the ideas more firmly in their minds.

Classroom and School Activities

Activities of many kinds are carried on in the elementary-school classroom and in the whole school. These activities serve many different purposes and may be carried on at many different times, of course, just as explorations of the buildings and grounds may be. But, equally, there can be no question that they are avenues through which instruction in science may be approached and that they often reflect real interest in science.

The possibility for using classroom activities as a place to begin science instruction, of course, varies with different classrooms. A specific illustration is the use of plants in the classroom as a place to begin some science instruction.

A window box or pot of growing flowers may be a source of science learnings. One or two children could have the responsibility of caring for the flowers daily. They should realize the urgency of giving plants the things they need—sunshine, food, water, and soil. However, it is not enough for them to see the necessity for these things. They should express them verbally, record, and refer to them from time to time if the majority of the class is to learn the principles underlying the growing of plants. Here, too, is an opportunity in a simple way to introduce the children to scientific procedures by having control plants—that is, one plant which receives water, light, and soil; another receiving water, but no light; another light, but no water—and

Photo Lab, New York State University, Geneseo, New York

Boxes of plants, cared for by the children, not only beautify the room but serve as avenues through which instruction in science may be approached.

recording the results. From their observations and recordings, they could draw some conclusions and make a statement of the principles which were demonstrated, as is done in the class record or experience chart that follows:

How the Sun Helps Plants

We have plants in our room. The plants need water and sun. We put some plants in the sun. We put some plants away from the sun. We watched them grow for a month. Flowers that had the sun were pretty and red. The plants that did not have it were pale. The sun's light causes plants to grow.

After children have had the care of plants, with encouragement they will become interested in seeds and kinds of soil. A group story made by the second grade tells how they experimented with seeds.

Seeds

We brought dried bean and dried corn seeds to school. We put the seeds in water and let them stay all night. The next morning, the seeds had swelled. Their coverings had burst, and we saw a tiny baby plant. We put the blotter around the inside of the glass. We put a little water in the bottom of the glass. The next day, the roots and stems had started growing. We planted some seeds in soil. We cannot watch them grow in dirt, but we can watch them in the glass.

After children have learned that water is essential to the growth of plants, an experiment to show the best kind of soil will interest them, since most plants get their water through the soil.

Some children in the first grade had plants in their rooms but had not seen them grow from the seed. After discussing the needs of plants, the teacher took the children on a walk. They saw some sandy soil and some clay. They brought some of each back to school. In one jar they put sand. In one they put clay. In another they put a mixture of clay and sand.

They poured the same amount of water in each. They soon learned that a seed in sandy soil would not have time to absorb the water because it drained off too quickly; that the seed in clay could not get enough because it was too compact for the water to seep through; but that the one in the jar with the right mixture would get the amount of water needed for growth.

This, of course, led to the discussion of the way the plant absorbs water. A simple experiment to demonstrate this was told by a group on a chart.

How Water Rises in Plants

We put a celery stalk in a glass of water. We added a teaspoonful of red ink to the water. We let the celery stand in the sunlight for two hours. The water traveled up through the stalk and made the veins red. The red ink helped us see how water rises in plants.

This experiment could be tried with any white or lightly-colored flower. A carnation, a lily, a white rose—all show the color plainly. One group used a carrot and blue ink. In fact and as has been said, children should do many experiments before generalizing.

From their observations, they will learn how food is carried to every part of the plant. They like to learn the names of the parts, and why we eat the leaf of one and the root of another. The changes in plants from season to season and the effect weather has upon them are of interest to children. Much of this can be learned through discussion of their observation—sometimes things the individual child has noticed, sometimes things the group has seen on trips with the teacher.

A sand table in the classroom can enable children to see how severe rains or floods wash seeds and plants away and how poor drainage causes seeds to decay.

An outdoor garden is a joy to children, and from it, they may learn many principles of science. In some climates, it is necessary to plant seeds in the classroom and transplant them to the ground at a time when one can be reasonably sure there will be no more killing frosts.

There are many, many classroom activities which may become a place to begin science teaching. An attempt has been made to show possibilities in one activity (the observation of plants) rather than to list a number of different possibilities. Other possibilities through other aspects of science may be found throughout the different chapters in this book.

The Discussion Period

Almost every teacher has a discussion period daily to talk over the routine of the classroom and to make plans for work. Some teachers have used discussion periods effectively to interest their pupils in their surroundings and to make them curious about natural phenomena. When the daily plans for work are completed, they allow the children to show something of interest they have brought. From time to time, by bringing such things as a gaily colored fall leaf or a picture of a cow being milked by an electric milker, a teacher herself can lead the children to notice things in the outdoor world more carefully. Her contributions will encourage them to bring more stimulating things to the group. She can lead the group into discussions, and sometimes into further studies of worthwhile specimens. Things not suitable for additional educative experiences can be considered

by the teacher and class together and dismissed with brief, tactful remarks. With this type of guidance, the articles brought by the group will steadily become better ones for study. In many instances, specimens brought for the discussion period have been the incentives for starting the science corner, for organizing science clubs, or for launching a unit of study in science.

Daily News

In the elementary school, teachers often have an early morning period set aside for news at which time pupils read or tell items of specific interest to children of their age. If the teacher contributes an article related to science, it will make the pupils more alert in looking for similar ones themselves. The daily papers, the little newspapers that are published specifically for children of all ages, and the magazines frequently publish science articles of interest. Sometimes the children tell news about themselves or their families, a visit to the seashore, to a museum, or to an observatory. The boys and girls who carry on science activities outside of school hours often have interesting things to tell that they have read or seen. Some experiments that they do are of value to the group if described or demonstrated to them. All such reports may lead into the study of science.

The Science Corner

It has often been said that if an elementary group is receiving a sufficient amount and variety of enrichment in the classroom, there will be visible evidence of interest in literature, industry, art, science, and other subjects. A permanent science corner is a means of stimulation and an aid to a group. If the interest in science is to be sustained and extended, a table kept in readiness at all times for experiments with a magnet, a magnifying glass, glass jars, and a one-burner electric stove should be provided. In the intermediate school, more equipment will be needed, such as dry cells, a prism, and a telescope. In Chapter 9 there is a discussion of equipping an elementary schoolroom for science.

A bookcase with some shelves containing science books, attractively displayed, and others ready for specimens that might be brought to school would also be needed. A bulletin board

reserved for news items and paintings made by the pupils is a stimulus to them to make contributions of those types.

Collections and Museums

From time to time, the science corner of the classroom may be used for displays. A grade might become interested in toys that operate according to principles of science—in an electric train or in a fish pond from which the fish are caught with magnetized bait. Individuals or groups might plan exhibits of shells, rocks, birds, or pictures.

A committee that is changed at regular intervals might take the science corner as its responsibility and see that it is in order, attractive in appearance, and always ready for use. The science corner, if used correctly, should be constantly changing from week to week, as the interests of the class are being extended and deepened. The alert teacher will not permit it to become a static thing.

There is little or no value in a collection of bottle tops or pictures of movie actors, but children frequently spend time and energy on them. However, if the child has the inclination to collect, the wise teacher will attempt to lead his interests into broader fields or to guide him into a real study in connection with what he has. If a collection is worthwhile, it will broaden the child's knowledge and will stimulate him to do some research.

Frequently a hobby started in youth will continue to be an avocation through life. Occasionally, one will become a vocation. Two boys started a rock collection. Supervisors going from school to school spread the news of the excellent exhibit which the boys had made of the rocks found in their state. The boys received so many requests from people who wanted to borrow it that they made two or three similar collections and charged a small fee. This eventually grew into a real business.

A class museum may be started from a collection made by a group or by an individual. If a suitable place is prepared in the room to exhibit articles, children will, with encouragement, bring various articles, such as fossils, shells, rocks, bird nests, moths, and butterflies that will start a museum. The class should feel the responsibility of keeping it in order and up-to-date. Articles

should be classified and arranged according to classification. They should be labeled and with them should be notes telling their properties and their use.

Some items will be permanent. A good collection of rocks or shells might remain in the museum permanently and be a stimulus to the boys and girls to make their own individual collections. Fossils or Indian heads should also be permanent. Articles of less durability, such as seeds or old birds' nests, should be removed before they disintegrate.

Books of identification help in preparing labels for a rock collection.

Fort Wayne Public Schools, Ind.

Science Clubs

An organized club has a special appeal to boys and girls in the middle-elementary grades. Children usually will show more zeal in carrying out projects initiated by themselves or by their fellow club members than on any required school subject. Therefore, school science clubs are of real value as an avenue of approach to instruction in science. The membership of the club may be made up of children from three to four classes who are particularly interested in some phase of science.

The club may or may not be a part of classroom routine; or it may be a combination of non-classroom activity and classroom activity. Many successful science clubs have their members spend a great deal of time outdoors. In any case, the classroom is probably the best place for a central meeting place and for necessary indoor activities in inclement weather. The members of the club may want to perform many experiments in the classroom, which they will use as a sort of laboratory in after-school hours. They may make collections or have hobbies of studying birds, insects, or stars in out-of-school hours. The entire class may well profit from hearing the boys and girls of the science club tell about the things they have learned from their interesting activities. Such reports will cause others to become enthusiastic and want to join.

Science in Other School Subjects

In the field of Social Studies, Reading, Music, Art, and other school subjects, the understanding of certain principles or facts of science makes the other subject more meaningful. This, of course, provides a very profitable avenue for the beginning of science instruction. This point will be developed in more detail on pages 156–158. It is mentioned here because learning subjects is always one of the activities going on in a school building.

Field Trips

Field trips are made on many occasions, not only in connection with science, but also in connection with other subjects of study, and for many purposes. From any trip, leads into science will be

found. In Chapter 8, entitled "Using the Resources of the Community," field trips are discussed in detail. In Chapter 10, "Audio-Visual Aids for Science Teaching," field trips will again be discussed in some detail.

Incidental Happenings and Science

The dangers in using the incidental approach to teaching science are great, as will be pointed out. They are so great, indeed, that the incidental approach can be recommended only for its aspects of interest and of drama and for the identification of science all about us.

An explanation of what the incidental approach to teaching science is will indicate its haphazard nature. It depends upon what happens in the classroom or in other surroundings of the child. The incident and the child and the teacher (guide) must come together at a particular moment or at a moment near enough to the incident to approximate its high tide of dramatic interest. The incident may come at any time and can seldom be anticipated. Facts and laws of science which are necessary to an understanding of the occurrence may or may not be within the range of the child's previous knowledge or level of growth. The point is that the happening is unforeseen usually. It may never happen. It may happen every year, or even every month or every day. It depends absolutely upon locality. The parent-teacher guide can make no immediate preparation for it. It is, indeed, a haphazard approach.

The great advantage that the incidental approach to teaching has over all others is that something has happened. It is likely to be something dramatic. The child's whole interest is involved in it. Descriptions of a series of incidents, with analyses of their content of science, will make the approach clear.

A Moth Flies into the Classroom

A moth flies into a sixth school-year classroom. It flutters about and at last comes to rest. The children crowd around to observe it. At least they watch it with interest if they are not allowed to crowd close. It is a beautiful creature, pale green, with long, graceful curves at the end of its spreading wings. Pale

green colored spots can be seen decorating its already beautiful wings. As the creature rests quietly, eggs are seen to issue from its thick abdomen. What is it? Why does it lay eggs here? Will the eggs hatch? What will come from the eggs? Is it a moth? Could we add it to our collection? May I find it in a book?

Questions pour forth if the children have been allowed and encouraged to express their curiosity.

The incident occurred in the sixth school-year. If it had occurred in any other year, its possibilities for teaching science would be different. The children would be on a different level of growth. If it happens in a class where the children have had much training in science, the possibilities will be different from what they are if the children have had slight contact with science. Differences in the background of teachers in preparation for science teaching will affect the possibilities for learning science from the happening.

What can be learned from the happening? The moth may be classified as a Luna. Other similar beautiful moths may be found in books. Collections of moths may be started. Differences between moths and butterflies may be studied. They are both insects. They have six legs. The antennae are different. Insects lay their eggs where the young can find food. Food of the Luna caterpillar may be investigated. The newly-laid eggs may be placed on food the young will eat. The eggs may be observed, and if they hatch, the young may be watched until they grow into maturity. Cocoons may be observed. The complete process of metamorphosis might be observed. The usefulness of the Luna moth or its harmfulness might be investigated.

This single incident might lead into a significant unit of subject matter in science. Several weeks might be devoted to a study of moths and butterflies or of insects in general. Equally, the incident might be a mere momentary flutter or flurry of excitement.

A Circus Comes to Town

A circus happens to come to the community. A second-year class might launch itself into a meaningful unit of work from the incident. Animals of other lands might be studied, with charts

and drawings showing them. Books might be read, and much might be learned about how different animals protect themselves and care for their young. The habits of different animals might be studied, with comparisons between wild and domesticated animals. Animal homes might be a part of the study. Different kinds of food the animals eat and their usefulness or harmfulness to man should be studied.

The second-year class as a whole group, or members of the class, might attend the circus with adequate planning for the trip. The method of making accurate observations for gaining accurate answers to the problem-questions might be stressed. Every trip is a happening from which the method of accurate observation and recording may be learned. Some trips are purely incidental to the teaching of science; but the point is that from these incidental happenings on a trip, something of significance in science may be learned. The trip to see the circus came because the circus happened to come to the community.

If a unit of work develops from the appearance of a circus in the community, the whole second-year classroom will surely give evidence of it. The coming of the circus may, of course, call forth only going to the window or outside to the sidewalk to watch the circus parade go by. Even that meager use of the incident would bring science of significance to the pupils. They would come to know that animals differ greatly in size, in form, and in color.

Unusual Weather

Conditions of the weather, changes that call for differences in clothing, and other needs for protection are constant in most localities. Incidental happenings due to weather, temperature, and seasons are inescapable. They account for the studies of a seasonal nature that are to be found in all elementary-school classrooms. Birds, leaves, flowers, seeds, and trees are collected, exhibited, and named in the classrooms from the nursery school upward.

Incidental happenings related to weather and seasons may mean only naming. That, however, is a part of science teaching, although the least significant part. An acquaintance with the

environment is stimulated. The child is made aware of changes in weather, in the seasons, and in plants and animals because of those changes. Those are gains for understanding the world around, and that is one of the aims of teaching science in the elementary school.

The sudden fall of snow is observed through the schoolroom window. An interest in what makes the snow may arise from the incident. If a rainbow is observed by a child coming to school, or by all of the children through the window, the question may be about the cause of a rainbow. Obviously, either of those incidents, or a hundred others that weather and seasons might bring, could lead into science. The effective teacher would not pass them by with a casual answer. They would lead easily into experimentation with forms of water and with prisms and how water acts as a prism.

The number of incidental happenings in connection with changes in weather and seasons is legion. The possibilities of using them for an approach to teaching science are equally legion in number.

An electric storm approaches, spends itself, and moves away. A small child is frightened by it. He may be helped to understand that it is a part of many storms and be reassured. If the child is 12, he may wish to know what causes lightning. He may ask how one can know how far away the clap of thunder started. This incidental happening has led the older child and even the smaller one, to a less extent, into a realm of scientific fact and generalization. If the teacher is merely soothing or impatient, the child is prevented from knowledge. If, together, the teacher and the child try to understand conditions and causes, the program of teaching science in the elementary school will be greatly fostered.

Throughout this presentation of descriptions of incidental happenings that might lead into understanding the facts and laws in the area delineated as science, the teacher's attitude and method are stressed. They have a great bearing upon the use of incidental happenings for all kinds of purposes in the classroom. Incidental happenings may confuse a child. They may lead to further development of interests.

Children's Unexpected Exhibits

A mouse or snake brought to school to scare the other children has often brought on the strictest measures of disciplinary control. Rubber bands, matches, pea-shooters, and gadgets may be only dangerous annoyances. Mouse, snake, and all the other annoyances are incidental happenings, and they may come at any time. They can be turned into valuable approaches to science teaching.

A mouse or a snake can be kept in the classroom. Proper homes could be made for them. They could be fed. Are all mice harmful? Is a fieldmouse like a house mouse? Can a mouse be tamed and made into a pet? How is a mouse like all other animals? How does a mouse differ from all other animals? Are all snakes harmful? How can you know the harmful snakes? What does a snake eat? Is a snake a warm-bodied animal? In what ways is a snake like all other animals?

Pea-shooters, gadgets, rubber bands, matches, are apparatus for scientific experiments. The rubber bands and matches may be placed in the science corner for use. Why should matches be kept in a tin box? What gives rubber its power to stretch? What is elasticity? Is rubber like a wound-up steel spring? What principle of heat or energy is used in making the gadget?

If a teacher considers such incidental happenings as these which have just been described as approaches into a program of science, it will be apparent that every day, and almost every hour, in the classroom brings them. Nuisance, annoyance, dangerous weapon, means of escape from learning? Under certain conditions, they are. But they can be turned to account for learning in many cases, and not just alone in the area of science. Attitude and method again must be considered. The child's interest of one kind or another is undoubtedly present. Illustrations of incidental happenings that could lead into valuable learning experiences in science might be accumulated indefinitely. At least twelve master's theses in education or articles for professional magazines should be written by teachers who would keep detailed records of incidental happenings in their classrooms for one year and would analyze those happenings into

their suggestions for a program of teaching science. One should be written for each of the years in the elementary school. One should be written for each school year for rural areas, and one for urban areas. More might be written for different regions. It cannot be emphasized too strongly that the incidental happenings are closely related to special localities.

From Incidental Happenings to Organized Science Instruction

Incidental happenings often lead into formally organized subject matter in some area of science, or at least into general concern to understand facts and principles of science which might help explain that aspect of science.

A teacher who was starting work in a new school decided to visit the school ground and neighborhood two weeks before school opened to discover the possibilities of science and social learnings for her pupils. The school was situated on the edge of town, and at the back was a great grove of trees. As she entered the woods, she met three boys, two sixth-grade boys and one who was in the third grade. One of the older boys carried a rifle in one hand and three birds he had just killed in the other—a catbird and two robins. The incident shocked her and made her realize that the school as a whole had much to do in changing the attitudes of the pupils toward birds. She knew the study of birds had been made so often and, in many instances, so superficially and ineffectually, that some teachers were a little wary about attempting it. However, knowing that it was a topic of natural interest to children, one that could easily be studied firsthand, she embarked with her children on such a study at the opening of school.

In another situation, some robins built their nest in the shrubbery just outside a first-grade room in the heart of a city. The children put a line on the floor of the classroom near the window. They dictated this sign to the teacher.

Observing Birds

If you come to this line, please be quiet and move slowly. We want to watch our robins. If we make too much noise, they might go away.

Members of the group went into every room in the school telling them about the birds and asking them not to play near the bushes. They kept a diary of day-to-day activities of the birds, from the making of the nest until the baby birds hatched and flew away. They illustrated their stories and finally made them into a book.

A third-grade child found a mockingbird's nest just outside his garage window. He and his neighbors kept watch as often as they could and from time to time reported to their class. They saw the mother and father bird alternately bring worms to the babies. They saw one of the parents clean out the nest. They learned to recognize the calls the birds make when they want help. Once during their observations, a man came down the path under the nest. The mother bird called frantically to the father bird, and at once he flew in from the woods and dropped down in the path directly in front of the man, diverting his attention from the nest. By encouraging the children in that neighborhood to make frequent oral reports to the class on the activities of the birds, the teacher stimulated other boys and girls to make feeding stations and to study birds around their homes.

The whole class went to a park nearby. With them, they took crayons and mimeographed outlines of birds. They sat quietly in a group and read or talked in low tones. When a bird came near, they listened and watched. Then they colored a properly selected mimeographed outline like the birds they saw. They learned that by sitting still in one place they often saw as many birds as when they took long walks.

They visited a neighboring garden and learned from the owner that some birds were helpful to the plants and some were harmful. They decided to learn for themselves which birds should be encouraged to visit the garden and which should be kept away. From this, they had another illustration of the interdependence of plants and animals, the insects eating the vegetables grown for man's use and the birds eating the insects that were destroying the plants.

Incidental happenings at home and school, indeed at any time and place, will often lead into some area of science. They

cannot be depended upon to provide the broad instruction that the elementary-school child should have in science; but they furnish interest as almost no other avenue for teaching science does. If the teacher is not afraid to say, "I don't know, but I think we can find out," an incidental happening can be made to contribute immeasurably to a program of the understanding and use of science.

Science in Experience Units of Work

In some classrooms the schedule of work for each day is flexible. Time can be taken for discussions and follow-up activities connected with incidental happenings and for following all the other avenues that were examined in Chapter 5. In many of them an approach through units of work is followed in learning subject matter and acquiring skills.

Many present-day teachers follow in general the pattern of the child-community-centered school. Interests of the children largely control, under careful guidance, what will be found going on in the classroom. Because the interests of children are personal, activities in those classrooms will be colored by the children's environment and will be enriched by the use of resources of the community. Much constructive, manipulative and dramatic activity will accompany pursuit of their interests in ways satisfying to the children. The periods set up for the day will be adjustable, subject to immediate change and often varied from day to day. Significant selections from many subjects of study will be used to give larger meanings to whatever the pupils, individually or as a group, wish to learn. Work being done during such periods of unified approach to learning in connection with a specific interest is called an *experience unit of work*. The terms *center of interest*, *large unit procedure*, *experience center*, *activity center*, *project*, and even *core curriculum*, at times, are used to mean practically the same procedure. As it is used here, the term *experience unit of work* means a large theme about which cluster the purposes of individuals in a class. The aim of the teacher is to give greater meaning to the purposes of the class and at the end of the unit of work to be sure that the pupils have gained significant social meanings, have explored a rich background of culture,

have practiced old skills and learned new ones, and have felt more sure of themselves as adequate participants in human affairs.

Machinery, for example, might become the basis for an interesting and educative experience unit of work. Around the interest created by discussion of trips made in airplanes or on tractors, work with construction sets or machines in the school shop, an exhibit of machinery in a showroom in the community, play with mechanical toys, or experiences of other kinds with machinery, could, and often does, grow almost the entire work of a class for a period of six weeks or more. Reading of the most purposeful kind, use of oral and written language with emphasis upon vocabulary and effective form, use of reference books, problems in arithmetic and general mathematics, geography and general social studies, art and music, health information and practices, spelling, handwriting, science, and, indeed, all the skills and information usually included in daily programs of a class would legitimately find places in developing such a unit of work. Trips, interviews, experiments, constructions, school assemblies, and periods of cooperative planning would be needed to round it out. Maps, charts, graphs, and illustrations would be necessary. Many resources of the community would make contributions to it.

Some teachers have been known to develop their daily programs in that unified way and have felt rewarded by the interest, enthusiasm and growth in information and use of skills by their pupils. The entire work of a school year might consist of a succession of such units of work.

If such a plan were followed, how would instruction in science be given? The facts and generalizations of science would contribute to an understanding of machinery just as reading, mathematics, spelling, geography, history and other subjects of study would. Each would supply relevant subject matter or skills for pursuing the interest to a worthy, satisfying conclusion. The level of child development on which the unit of work was carried out would determine the relevancy of the subject matter in science as in any subject of study.

Suppose the unit of work, Machinery, were being carried out in the fourth year of the program of science in the elementary

school. The teacher in making plans for the unit of work, considering only the area of science for the moment, would think of facts and generalizations, experiences and experiments, trips and observations with which the pupils during the three previous years of work would already have become acquainted and of those others into which their interest would probably lead them. The children at the beginning of the unit of work would help list what they already knew and had done.

It would be reasonable to suppose that children on their level of development would want to know the uses of different kinds of machines, how many kinds of machines are used on a large farm or in a modern home, who invented the first machine, what causes friction, how machines are run, and other facts and principles about machinery. During the progress of the class through the unit of work, other questions and problems would be listed and answered. Simple machines such as lever, inclined plane, wheel, and pulley would be used in performing experiments. Experiments to show how to decrease friction, what power steam has, and how electricity is used to help make machines work would be performed. Trips to a machine shop, to a showroom or an implement store, or to other places where machinery could be seen would be taken. Pictures of machines and stories about machinery would be collected from catalogs, newspapers, magazines and other sources and studied. The effects of new inventions of machines upon different kinds of work and workers would be explored. Drawings and charts from actual observation and many oral, written and pictorial reports would be made. Pupils and teacher together would assemble reference books which could be kept in an easily accessible place such as the science corner. At the end of the unit of work, tests to show what had been learned about machinery, charts to show what experiments had been performed, and possibly a small science fair to show outcomes of the whole experience unit of work would be among the testing devices that might be arranged.

A unit of work on Machinery would be manifestly overweighted with science. Other subjects of study, however, would have less important but no less essential parts to play in developing units of work that are so overweighted in one direction.

When experience units of work are used in teaching, separate subjects disappear in the unified area, each contributing its meaningful part to the whole. If a school is equipped with a few sets of books for teaching reading, with geographies, with histories and with books of science, almost any unit of work can be enriched by the reading that will be done in connection with it. Such books, even adopted texts, then become largely sources of information pertaining to the content of the unit of work. This does not mean that there is no work being done except in connection with the unit of work. Reading and work on other skills would be done to increase the skills of those individuals who needed to increase that skill. Reading for pleasure would continue throughout the unit of work, of course, as it should no matter what organization of classroom or curriculum and what procedure in instruction were used. Experience units of work demand the wide use of books of reference of many kinds and make use of all generally essential skills. They do not preclude other work from being carried on in the classroom.

Other examples of units of work will show how much science can contribute to them. A unit of work on Textiles came about after children in the fifth school-year had seen an interesting exhibit of different kinds of cloth at one of the textile mills in an industrial center. This unit of work, unlike the one about machinery, is chiefly social in content, but the teacher and pupils together found many areas of science to be explored as they progressed through the study. This is a report of the science covered.

Fifth School-Year—Unit of Work—Textiles

Health—facts and generalizations:

Cottonseed oil has food value; used for salad oil. Cotton is a suitable fiber for clothing because it admits air, absorbs moisture, and is easy to clean.

Wool is one of the warmest textiles because it holds little pockets of air between its loose threads and among its scaly fibers. Air is one of the poorest conductors of heat and the warmth of the body does not easily escape through woolen clothing.

Linen aids in keeping cool because the threads are of uneven thickness, necessitating a porous weave through which the heat of the body easily escapes.

Clothing should be worn to suit the temperature and the weather. Clothing protects the body from cold, heat, rain and exposure. Comfortable and appropriate clothing aids good health. Clean clothing helps to keep the body in health. Water, fresh air, and sunshine help to keep clothing clean and sanitary.

In some branches of the dye industry, conditions are injurious to health. Good ventilation is important in factories and crowded places. Dye discolors and roughens skin.

Science—facts and generalizations:

Formation and composition of soil help determine crops; need for rotation of crops; need for fertilizer. Clay, sand, and loam furnish food elements for cotton plants; studies of soil conditions of the Mississippi Delta and of Bombay, India; samples of different types of soil examined and analyzed. Cotton plant requires mineral food; potash, phosphate, nitrogen.

Some plants require a long growing season. Cotton grows in warm, moist climates. Cotton plant requires much sunlight and heat for growth. Leaves of cotton plant are arranged to receive a maximum of sunlight. Leaves of plants manufacture food, and flowers produce seeds. Cotton plant reproduces by seed; lint serves as carrier for seed.

Plants help to furnish clothing for man. Our clothes come indirectly from the soil.

Bacteria cause diseases in cotton plants; wilt and rust are caused by bacteria. Some insects are enemies to cotton and should be exterminated; boll weevil; some caterpillars; methods for fighting them.

Cotton is pure cellulose; soaking in certain acids changes it to gun-cotton, a very powerful explosive. Cotton fibers are not dissolved by lye as are wool, silk, and hair. Cotton fibers are three times as strong as wool. Mercerization adds to the strength of cotton cloth and makes it shine like silk or linen. Silk does not burn so rapidly as cotton.

Most dyes are made from chemical compounds found in coal tar. Some barks, berries and roots are still used for making dyes, especially in the home as the methods for making them are simpler than those for making coal-tar dyes. Dyeing involves a chemical process. Cotton dyes must be boiled to be most successful. Salts of metals act as mordants.

Silk making is a part of the life history of the silkworm.

Some animals have various means of protection; sheep protect themselves with horns and sharp hoofs; from cold by warm coats.

Evaporation is constantly taking place as air absorbs moisture. Warm air absorbs more moisture than cold air.

Many agencies are constantly at work changing the earth's surface; rivers such as the Mississippi and the Nile, glaciers, weather, volcanoes, earthquakes. Power of falling water may be utilized for turning wheels; this energy may also be transformed into other forms of power and into heat and light.

Inclination of the earth's axis and revolution about the sun give seasons and zones. Latitude and altitude are the most definite controls of climate.

Progress in manufacturing requires an inventive people; gin, spinning jenny, water frame, mule frame, modern spinning jenny and automatic loom were invented by people who kept working to perfect devices for improving the manufacture of cotton cloth. The Industrial Revolution was dependent upon the following inventions: steam engine, spinning jenny, mule frame, loom.[1]

On the following pages are other examples of the contribution of science in the world about us to experience units of work. Each of the reports from which these are taken, with only slight editorial changes, contained also facts and generalizations from the area of health. The reports were made by the teachers after the units of work had been carried out in their classrooms. They have been given for each school year except the fifth which has as its illustration the unit of work on Textiles.

First School-Year—Unit of Work—Keeping Pets

Science—facts and generalizations:

Animals are adapted to the place in which they live; fish in water—have fins and gills; squirrels build nests high in tree—can climb.

Animals can adapt to change in climate; some have winter homes—gray squirrel; some take long winter naps—frog, bear; some store food for winter—squirrels; some hunt their food all winter—rabbits; some birds go to warmer climates in winter—bluebird, humming bird. People take care of many animals so that winter makes little difference to them.

Most animals have ways of protecting themselves; claws and sharp teeth—cats and dogs; long legs suited to running—rabbits; wings for flying—birds; claws for climbing—squirrels.

Animals have different coverings; fur—squirrel, rabbit, cat; shell—turtle, snail; scales—fish; hair—dog.

[1] Tippett, James S. and Others, *Schools for a Growing Democracy*, Ginn and Co., 1936. (Selected and slightly edited from pp. 130, 161–164, 170–173.)

Some animals take care of their young; feed them milk or other food; protect them from enemies. All baby mammals need milk, the most perfect food. Baby dogs, cats, rabbits drink milk—good for children, too. Animals need sleep, rest, proper food, exercise and special care when sick, just as boys and girls do. Baby animals should not be handled much. Water, sunshine, fresh air and exercise are essential to life for most animals.

All life comes from life and produces its own kind of living organism. Learned something about reproduction from discussions about our pet rabbit and her babies. Nature's principles are invariable; squirrels, cats, dogs are always born with their eyes closed; chickens and birds are hatched with their eyes open; nuts get ripe at the same season each year.

Second School-Year—Unit of Work—
Where We Get Our Groceries

Science—facts and generalizations:

Man eats many kinds of vegetables, using one part of one vegetable and another part of a different kind of vegetable. Many different kinds of vegetables grow in gardens and on farms.

Fruits are important to man's diet. Different kinds of fruits grow in different places. Trees furnish us with many foods.

Man uses many animals for food. Man's food consists of grains, vegetables, fruits, meats and other animal products, and minerals. Milk is the most nearly perfect food. A variety of food is necessary for health. All food and the surroundings of food should be kept clean. Foods are preserved by canning, drying, and refrigeration.

Third School-Year—Unit of Work—Cooking and Foods

(Note that though the areas covered are the same as above, the science learnings are increased.)

Science—facts and generalizations:

Man gets food from plants either directly or indirectly. Most plants require air, water, sunshine and good soil to grow. Not many plants grow in dry or cold climates; rainy seasons in some places, irrigation necessary in others. Climate helps determine the plant and animal life of any region: citrus fruits in warm climate; bananas and pineapples in hot climate; grains and apples in cool climate; cows in climates where grass grows. Cows give milk to people. Sunlight gives leaves their color. Leafy vegetables supply iron.

Plants are reproduced by various means: underground stems—potato; spores—mold; bulbs—onion; cuttings—grape; budding—peaches; grafting—apple; seeds—corn.

Air and heat cause evaporation. Raisins are dried grapes; prunes are dried plums; apples, peaches, apricots and beans may be dried. Moisture, air, and warmth are necessary for the growth of bacteria. Canning and drying preserve fruits and vegetables. Chilling preserves fruits and vegetables. Water is essential to life and cleanliness. Water is turned into ice and used for refrigeration; into steam and used for sterilizing dishes. Pasteurization makes milk safe for use.

Air usually contains dust. Foods and surroundings should be kept clean. When we cooked, we sterilized vessels, kept hands and nails cleaned thoroughly, kept clothing clean, washed dishes in very hot water, washed fruits and vegetables thoroughly. When we went to the bakery, we noted that the bakery was kept clean, bakers wore clean white clothing, bread was wrapped in paper. Only well people should handle food. Many kinds of insects destroy crops and trees causing injury to fruit trees. Spraying is a good preventive.

Electricity is a source of heat. We get warmth from electricity; cook with electricity. Water freezes at 32 degrees F. Frost forms on very cold objects; frost and dew do not fall; dew is moisture which collects when moist air comes in contact with cool objects. Heating dissolves some substances. Water dissolves many substances. We heated water and put sugar in drinks. Ice prevents food from spoiling by keeping temperature low; bananas transported in refrigerator cars; food in ice box.

Water evaporates from rivers, lakes, ocean into air. It falls again as rain. Plants need rain. Evaporation goes on continually.

Weather forecasts are of great value to many people. They help fruit growers and truck farmers.

A variety of food is necessary to health. Eat a balanced diet—vegetables, grains, fruits, proteins, minerals. Food must be digested to keep the body healthy. Cows have four stomachs; humans one.

Third School-Year—Unit of Work—Airplanes

Science—facts and generalizations:

An airplane is heavier than air. We cannot see air. Air has no color. Air has weight. Wind is air in motion.

Planes cannot travel many miles high because there is not enough oxygen for pilot to breathe (sic). The earth is circled by

an ocean of air. The higher we go, the thinner the air becomes· We must have oxygen to breathe. Men are able to go into thin air if they carry tanks of oxygen to make up for the lack of oxygen in the air.

Airplanes fly because the motor keeps the propeller turning. The propeller is like a screw that goes through the air. Moving air gets under the wings and lifts the plane. Airplane wings are cambered so that wind blowing over them causes a vacuum on the top, and so the plane is pushed up.

Gravity pulls everything toward the center of the earth. The earth is nearly round, and if gravity didn't pull us, we would fall off the earth.

A dirigible is a balloon that can be steered. Dirigibles are lighter than air. Objects float in the air when they are lighter than air. Hydrogen and helium are the gases used for lifting. Hydrogen is the lightest gas. It is not as safe as helium. Hot air is lighter than cold air.

Airships are useful for long journeys. They carry heavy loads. Fog, snow, sleet, strong winds and thick smoke hinder aviation.

Man gets many kinds of metals from the earth. Airplanes are made of different kinds of substances, including metals. Duralumin is a metal from the earth and is often used in the manufacture of airplanes.

The earth is about 25,000 miles around in its widest part. It is about 8,000 miles in diameter.

Fourth School-Year—Unit of Work—The Story of Houses

Science—facts and generalizations:

Man has become an important determining factor of the environment of all life.

Evaporation is loss of water.

Climate in certain regions prevents weathering of stones.

Heat causes substances to expand; cold causes them to contract.

Electricity is a source of heat and power.

Insulating materials are not conductors of heat.

Baking clay changes it into a rock-like mass.

Weathering breaks up rocks.

Paint will kill germs.

During the progress of the unit of work, studies were made of how trees are turned into logs and lumber, bricks are made, glass is made, paper is made, limestone is made, asbestos is prepared for use, paint is made and iron is prepared for use.

SIXTH SCHOOL-YEAR—UNIT OF WORK—
LIFE IN MEDIEVAL TIMES

Science—facts and generalizations:

An accessible and healthful supply of water is essential to health. Wells or streams were the only sources of water for houses during the Middle Ages. Sanitation was unknown; bathing and shaving almost unknown. Sickness, disease and plagues were constant.

A balanced diet promotes good health. The diet of people at this time was mostly meat.

Monks made a blue paint from indigo. Shellfish furnished dye of a rich purple color for dyeing cloth. Monks made parchment from skins of sheep; can be made of other kinds of skin. Many plants can be used for dye.

Man has developed ways of lighting and heating as he has progressed through the centuries. Not much progress up to the Middle Ages. Castles were dark, damp and musty; poorly lighted and heated; narrow windows let in little light and not enough fresh air. Huge rooms, heated by means of large open fireplaces in the center of the room often built without chimneys, were never cleaned. The filthy, poorly ventilated hovel of the serf was worse.

This unit of work for the sixth school year has been given here because it might well be simply a report of the science which was learned in a unit of subject matter in history, enlarged and enriched as many units of that kind are from other content subjects.

The advantages which derive from using the experience unit of work as an avenue of approach to teaching science in elementary schools are that the learners have a purpose for what they learn with the favorable effect of interest and that the facts and generalizations which are learned find their proper places in a larger social setting. The learning of science is not an end in itself but a means to the end of social understanding when the experience unit of work is used.

The danger arising from using the unit of work as the sole approach to the program of science would be the same as the danger from using an incidental approach. Some significant items would be omitted from a complete understanding of

science, simply because they would not contribute to any of the units of work into which a child or group of children might go, and there would undoubtedly be useless overlapping as a backward glance at the reports in this section will show. The same dangers would exist if the approach through the contributions of science to other content subjects, now to be discussed, were used as the only approach.

Much meaningful and socially significant science can be learned if care is taken to locate and bring out the meanings, generalizations and facts of science in most of the experiences of life or in experience units of work carried on in school. Gaps would exist, however, and so it is recommended that science in experience units of work be only one avenue of approach to a well-rounded program of science.

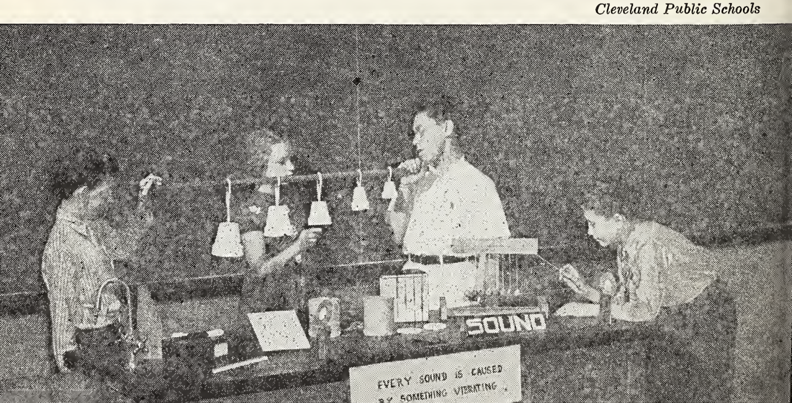
Science in Other Elementary-school Subjects

Often facts and principles of science are used in other school subjects and an explanation of them may require reference to books of information in science and may lead on into an interest in some aspect of science.

Music is a subject of study in the elementary school which becomes clearer if children know about vibrations in substances, about amplifiers, and about inventions that have made improved musical instruments possible. The approach to science from music may come from use of a tuning fork, from making drums or marimbas, or from attempts to improve the voice.

A study of vibrations in general may be an outgrowth of a discussion of sound in the music class.

Cleveland Public Schools



Geography is a subject of study in the elementary school which makes frequent use of facts and principles of science. Conditions of weather and climate, land and soil erosion, natural products, manufactured articles, water power and many other aspects of the life and conditions in different countries of the world are described in geography texts and references. Altitude, latitude and longitude, motions of the earth and the sun, rainfall, glaciers, zones of the earth, and many other words are used in connection with geography and with science. Any of them or any of the descriptions of countries might be of great interest to a class and become an approach into instruction in science.

In mathematics, approaches into science can be made in connection with instruments for making accurate measurements (thermometer, light meter, scales), in connection with studies of profit and loss (use of labor and machines to produce articles more economically), or in other connections. In reading, the approach into science comes from stories, poems or other forms of composition in which plants, animals, machines, inventors, inventions, superstitions, and other living or non-living things and factors in social life are mentioned or described at length. Reference to science will often make the author's meaning clearer. Sometimes the facts and principles of science are not correctly stated in literary compositions. Personification and anthropomorphism (giving inanimate things human characteristics) are often found in literature. Perversions of the facts and principles of science may add to the enjoyment of a piece of literature and may be allowed for that purpose, but the purpose should be clearly understood and the truth in so far as it is known given along with the selection. Animals do not use human language. Flowers do not wipe their eyes. Hundreds of such illustrations of misstatement of fact could be given. The author of such compositions has a purpose in the way he expresses himself, but his purpose is plainly not to teach science. Sometimes animal stories lead into interesting units of work on animal life, even if they are not true to facts of the animal's nature. The study of science which will go on in the unit of work or large unit of study on animals will correct any misconceptions given by literary selection.

Enough examples have been given to show that in other subjects of study, not only in geography, music, mathematics and reading but in all subjects in the curriculum of the elementary school, are references to facts and principles of science or to inventors and inventions in science. The reference may be stated directly or implied. In whatever way it is stated or implied, it may be an approach into a program of science.

The references to science that appear in other subjects of study in the elementary school are inadequate to meet the purposes for which instruction in science is given. Whole areas of learning in science would be omitted if only leads from other subjects of study were followed in planning the program of instruction in science. The approach would be as haphazard and unpredictable as would be the approach from incidental happenings. The references should be followed up, but such a procedure would not make a comprehensive program in science.

The "avenues" discussed in this chapter demonstrate the fact that, in the average school day, an elementary child encounters numerous references to scientific facts. If these references stimulate him to acquire knowledge, his life will be richer and his interests broader. It is the teacher's responsibility to note the ones that are suitable for the group and to direct the children's interests to them. They may be utilized for various purposes. They may stimulate a group to further study and grow into a science unit. They may be a means of acquainting the children with practical applications of laws and principles of science they have learned in other ways. They may merely be a means of making children more conscious of the fact that there are interesting scientific things all about them and that the world is full of fascinating things for those who are alert enough to notice.

Over-all Picture of a Classroom

The opportunities for science learnings in the detailed account of an elementary-school day given below would probably never arise in any one day. However, there is a possibility of one or two occurring in a day.

The children arrived and did their classroom duties before getting to work on their unit of study or their individual interests. One child watered the flowers, one arranged cut flowers, and one examined the aquarium and removed dead leaves. One recorded the inside and outside temperature on the board for the thermometer readings.

At the conference period following the work period, the child who watered the plants reported to the group that two of the potted plants were not looking as fresh as they should. He placed the pots on the floor in the circle so that all the children could see them. After careful observation, the class decided the soil in one was too compact for the water to seep through and that a little loosening of the dirt would help. Someone suggested that they try using some fertilizer on both as it had helped his mother's plants.

The child who cared for the aquarium said the fish were coming to the top of the water too often. One boy said that he had read that was a sign that they were not getting enough air. The discussion of oxygen in the water and its importance to animals followed, after which the group decided it would be wise to replace the water with fresh pond water.

In reporting the construction work on the unit of study, one child reported having cut his finger with a saw. It was a very small cut; but it bled. The teacher took advantage of the incident to discuss germs, how bleeding helps bring them out of the wound, and the importance of cleanliness, even with minor injuries.

One child told how hot the saw became when they were sawing wood, which brought up the subject of heat caused by friction.

One group read stories or poems they had selected and prepared to share with the others. The myth about the Great Dipper was one of the selections. A discussion of stars arose, which led to plans to visit the college observatory.

Every child washed his hands before eating, and the importance of sanitation in handling food was brought out. A blessing was said by the children, and they were encouraged to talk quietly as they ate.

During the next period, the fire alarm sounded. After the fire drill, a discussion was carried on about the necessity for fire drills, what to do in case of fires, and how to prevent them. Again the subject of oxygen came up, and the children learned that without it, fire would not burn; therefore, a good way to put out some fires is to smother them.

At 12:00, the lunchroom menu was written on the board, and every child took his pencil and paper to write down the articles of food he would buy. John, who was overweight, was advised not to get both ice cream and pie; and Mary was reminded that she was still underweight and, therefore, should never substitute anything for her milk.

When the music teacher came in, she discovered a piano key that was out of tune. She said a piano tuner should be called. Billy asked, "What makes a key out of tune?" The children who played string instruments were able to tell him that the string had probably become too slack. They learned something about tension, which stimulated an interest in other characteristics of strings, which eventually led into a study of sound.

Talking about the machines used in putting up an addition to the school is another approach into science.

Fort Wayne Public Schools, Ind.

The group was studying about the southeastern states. They learned that the invention of the cotton gin had made great changes in the lives of the people living in that section of the country. Other scientific inventions that had changed industries were mentioned. Some of the group wanted to study ways that science had changed the industries of the United States.

Summary

The avenues of approach to a science program are numerous and varied. The teacher may use incidental happenings, exploration of school building and grounds, science clubs, collections, units of work, science in other subjects, field trips, and many others. All of these are desirable approaches into a program of instruction in science. Each should be used, but even all of them together will not produce a rounded, comprehensive program. There is need for a carefully planned program in which all of the foregoing approaches may find their place.

Increase Your Understanding

1. Select fifty pages in one of the textbooks for use in the elementary school in your community. Analyze the pages for references to facts and principles of science. Are all the statements true to the known facts and principles of science?

2. Describe an actual incidental happening in a classroom. Give the classroom setting. Tell what science came up in connection with the incident. What instruction in science might reasonably have been expected to result from the happening?

3. What instruction in science should result from a trip by a class to the furnace room in your home or in a school you know? Describe the furnace room, using charts and drawings if necessary. Describe the class that makes the visit. Both room and class may be imaginary. Keep the facts true to a possible situation.

Additional Readings

Blough, Glenn O. and Huggett, Albert J., *Elementary-School Science and How to Teach It*, The Dryden Press, 1951. pp. 25–44.

Craig, Gerald S., *Science for the Elementary-School Teacher*, Ginn and Co., New York, 1947. pp. 26–46.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 93–98.

Chapter 7

The Planned Course in Science

THE avenues through which instruction in science may be carried on in the elementary school are varied, valuable, and usable. No program of science should neglect incidental happenings that lead from strong interest into learnings, content in science which belongs to large units of work or topics, reading from interesting individual books about some aspect of science and from supplementary reading books with science as their content, or the science learning which may accompany the study of other content subjects. No real program in science can be effective if it does not stem from the interests of children and take into account the level of development of the individuals who make classroom groups. The best program that could be devised would be one that an informed teacher and her group worked out together, provided the teacher scanned what was being done and what had been done for a whole year in the light of best thinking by such groups as prepared Part I, *Forty-Sixth Yearbook, National Society for the Study of Education*, "Science Education in American Schools," by Craig and other leaders who have listed areas to be covered and generalizations to be developed, and by groups who have prepared local and state courses of study and manuals or handbooks for teachers of science.

The report in the National Society's Yearbook suggests that by the end of each school year, children should have had experiences in these broad areas of science:

The Universe—Study of the stars, the sun, the moon, the planets and their interrelationships; causes of day and night, seasonal changes, tides, eclipses and the vastness of the Milky Way and of galactic systems beyond our own.

The Earth—Origin, formation of mountains, weathering of rocks into soil, erosion, volcanism, prehistoric life, and the forces that have changed and are changing the earth.

Conditions Necessary to Life—What living things need in order to exist, how they are affected by changes in the environment and by the struggle for existence.

Living Things—Variety, social life, adaptations for protection, life cycles of plants and animals, how they obtain food, their economic importance and man's influence upon nature.

Physical and Chemical Phenomena—Common physical and chemical phenomena such as light, sound, gravity, magnetism and electricity; changes in matter; and phenomena associated with radiant energy and atmospheric changes.

Man's Attempt to Control His Environment—In gardens, on farms, in orchards; inventions and discoveries; use of power and of minerals; his control over living things; his study of places he cannot reach directly.

Craig[1] suggests that by the end of each school year children should have experiences in these large areas of science: Beyond the Earth; The Earth; Conditions Necessary to Life; Living Things; Physical and Chemical Forces; Man's Attempt to Control His Environment. The topics which are listed under each of the main headings given by Craig suggest specific items of which the total program would be made. On pages 528–550 in Craig's book are given the generalizations which would follow, at primary, intermediate and upper grade levels, from the study of the topics.

Courses of study prepared by local and state groups take their cues rightly from sources such as the preceding two, but they are much more specific in their suggestions. This too is right, for they are designed to help teachers, not only to evaluate programs originating with the children under expert guidance of teachers

[1] Craig, Gerald S., *Science for the Elementary-School Teacher*, Ginn and Co., 1947, p. 44.

but also in many cases where the teacher feels inadequate, to know what kind of science experiences should be incorporated in the program.

Two outlines of courses of study for the first grade are included to illustrate the likenesses and differences of programs in different areas.

First Grade Science[2]

North Carolina

I. Observation of the Weather and Weather Changes Where We Live.

1. There is air all around us.
2. Changes in the air make changes in the weather.
3. We expect the weather to change from day to day.
4. Weather changes are helpful to plants and animals.
5. The temperature is one of the ways of telling kinds of weather.
6. Rain, snow, hail, sleet, dry, hot, are some of the names for kinds of weather.

II. Our Pets and Their Care at School and at Home. Types of Pets, Food, Sanitation, Habits.

1. Pets are dependent upon us for proper food and care.
2. Animals for pets should be kept clean, well-fed, and protected.
3. Each animal has habits of its parent or kind.
4. Some animals cannot live in homes different from their own.
5. Some animals live on land, some on the water, some under the soil.

III. Wind as Helper in Our Work and Play: Moving Toys, Drying.

1. Air is always all around us.
2. Wind is air that is moving fast.
3. Wind can move objects.
4. Wind moves boats.

IV. Things We Need to Keep Healthy: Air, Food, Sunshine, Water, Rest, Play.

1. All living things need air, water, and sunshine.
2. All animals need food, rest, exercise, and play to live and grow.
3. Cleanliness helps us to keep healthy.
4. Pure drinking water is needed by everyone.

[2] *Science for the Elementary School*, Publication No. 227, State Superintendent of Public Instruction, Raleigh, N. C., 1941. (Adapted from the bulletin prepared by Julia Wetherington and others.)

V. The Autumn Season: Changes we see in the plants in our yards and on our playgrounds.

1. Most plants change in appearance in the autumn.
2. The evergreen plant does not change.
3. Plants have ways of storing away food for the winter.
4. Trees do not die in winter; the leaves of many trees die.
5. Some plants die in the autumn and winter seasons.

VI. Observing the Way Some Objects in the Sky Behave: Sun, Moon and Stars.

1. The sun comes up every morning in the east; at noon it is high over our heads; in the evening it sets in the west.
2. At night the moon comes up in the east; it sets in the west like the sun.
3. Stars are always in the sky; we see them on clear nights. The stars give us some light.

VII. Different Weather Conditions Help and Hinder Our Play and Work: Rain, Fog, Clouds, Ice, Snow, Sunshine.

1. There is always some water in the air.
2. Water in air appears in different forms.
3. Different kinds of weather make us change our clothing, work and play.
4. Rain, snow, sleet, hail, fog, dew, and frost come from water in the air.

VIII. Animals That We Know and Hear about Get Ready for Winter in Different Ways: Squirrels, Birds, Bears, Snakes, Woodchucks.

1. Every animal has some way of helping to take care of itself in the winter. (Adaptation.)
2. Man and animals must store away food for winter.
3. Some animals sleep in winter; some stay in the ground; some build special homes; some look for food.
4. Some birds go south in the winter.

IX. Watching and Caring for the Birds That Live near Us: Appearance, Food, Winter Habits, Nests.

1. Birds that stay with us in winter should have our protection and food.
2. Birds eat bugs and worms on plants.
3. The parent birds (robin) look for food for their young.
4. Birds have different places for and types of homes.

X. The Spring Season: Changes we notice in the plants and animals about us in the spring.

1. The birds return to build nests and raise their young.
2. Buds, leaves and flowers come out on the trees.
3. The fields, grass and tree foliage look green.
4. Many animals change their habits and homes.
5. Many animals that we call insects appear.

XI. Seeds Start New Plants.

1. Some new plants come from seeds.
2. The seed has within it the beginning of a new plant and the food for it.
3. A plant that grows from a seed produces flowers.
4. There are many different kinds of seeds.

XII. Some Things Magnets Will Do.

1. A magnet will pull only certain kinds of objects to it.
2. A magnet pulls iron and steel objects to it.
3. Magnets will not pick up glass, wood, paper, cloth and rubber.
4. Machines and magnets help to lift heavy loads.
5. Levers and wheels are simple machines.

First Grade Science[3]

New York State

I. There Are Many Kinds of Living Things on the Earth.
Plants and animals live almost everywhere on the earth.

a. Animals live all around us.
b. Animals eat different foods.
c. Animals have different ways of moving about.
d. Most plants cannot move about as animals do.

II. Earth Conditions Are Changing.
Our earth is made up of air and water and land.

a. Land is made up of rocks and soil.
b. Water is found almost everywhere on the earth.
c. Air is all around us.
d. Plants and animals must have water and air.

III. Matter and Energy Are Subject to Many Changes.
Air surrounds us.

a. Air takes up room.

[3] *Science, A Program for Elementary Schools*, No. 1224, New York State Education Department, Albany, N. Y., 1942. (Adapted from the bulletin.)

b. Wind is air that is moving.
c. Air has water in it.
d. Air helps fire burn.

IV. The Earth is a small part of the universe.
The sun, moon and stars are in the sky.

a. We can see many things in the sky.
b. The sun gives us light and heat.
c. Light comes to us from the moon and stars.

V. Plants and Animals Survive Many Changes.
Plants and animals are active in spring.

a. The days get longer in spring.
b. Trees begin to grow in spring.
c. Seeds sprout and grow in spring.

VI. Living Things Are Interdependent.
We get our food from animals and plants.

a. We eat various parts of plants for food.
b. Some of our food comes from animals.
c. Some foods are better for us than others.

The staff of the Holcomb Campus School at Geneseo, New York, under the direction of G. R. Megathlin a few years ago summarized their science program by topics and understandings in the different science areas.[4] The understandings for the fifth grade are reproduced here to illustrate another type of local program.

Biology

Adaptation—how living things can live in different places.

It is almost impossible to find any kind of place on the earth where there are no living things.

Plants and animals can live in a particular environment because their structure fits them to live there.

In water plants, their structure makes it possible for them to stay alive in and to get their food from the water.

Land plants have special parts which enable them to live on land.

The structure of water animals helps them to move through the water, to get food, and to take oxygen.

Land animals have parts which make it possible for them to get oxygen from the air, to keep their bodies from drying out, and to move in order to get food from their surroundings.

[4] Unpublished faculty study, used by permission of Gerrard R. Megathlin.

Plants adjust themselves to seasonal changes.
Some keep alive by dropping their leaves and stopping food manufacture.
Others send up new shoots from the roots.
Some scatter seeds for a new generation before they die.
Animals meet seasonal changes through migration, hibernation, or changes in body covering.
Animals living in certain environments must have special structures to protect them from their enemies.
Man has many highly developed means by which he meets seasonal changes and protects himself from his enemies.

Migration—how and why birds and animals migrate.
Migration of birds and animals is their movement, each spring and fall, from one type of region to another.
There are different explanations of the reason for migration.
Some birds are summer residents, some are transient residents, some are winter residents, and some stay all the year.
Migration is orderly and follows a quite definite route.
Time of day, time of season for migration, and distance and speed of flight vary greatly and depend somewhat on the structure of the bird.
Scientists differ in their explanation of how birds find their way during migration.

Geology

Earth Changes—how the surface of the earth changes.
The surface of the earth is slowly changing every day.
Mountains are being worn down, land is rising, lakes are being formed or being filled, valleys are being widened and deepened, soil is being formed and carried to the ocean.
The forces of moving water, temperature changes, moving air, growing plants, glaciers, volcanoes, and moving animals are making changes in the earth's surface.
There are many different types of surface features in the United States.

Chemistry

Elements and Chemical Changes—what materials are made of.
Every kind of material has characteristics of its own.
Our use of many materials depends upon their characteristics.
The litmus paper test is one way to check for an acid characteristic.
Materials can be changed into entirely new and different materials. This is called a chemical change.

Chemical changes are happening all around and within us and are important. Life is possible only because of chemical changes in the foods we eat.

There are about 100 different known elements in the world today.

These elements can be joined or united through chemical changes to make many different kinds of materials, some of which are very useful to us.

Some chemical changes are harmful, but we have ways to stop, to control, or to avoid them so that they cause no harm.

Meteorology

Air.

Air takes up space.

An ocean of air surrounds the earth.

This ocean of air grows less dense as it gets farther away from the earth's surface.

Air has weight.

Air can be compressed into a small space.

At any one point, the air presses equally in all directions.

Air expands when heated.

Air contracts when cooled.

Air is made up of oxygen, nitrogen, and carbon dioxide.

Weather—why the weather changes.

Weather is the condition of the air around us at any particular time, while climate is the general weather conditions over a long period of time.

The temperature of the air is always changing.

Temperature changes depend upon location, condition of the sky, and wind.

When air is heated, it expands and gets lighter.

Cold air presses down harder than warm air because it weighs more per volume.

Air pressure is changing all the time and can be measured by the barometer.

Cold air cannot hold as much moisture as warm air.

Wind blows because air varies in temperature and pressure over a wide surface of the earth.

Rain, snow, hail, sleet, dew, frost, and fog all are made by moisture coming out of the air because of varying air conditions.

Condensation and evaporation of moisture are caused by air conditions.

Forecasting the weather can be done by scientists who have studied weather and watched its changes for many years.

Forecasting the weather is a great help to people in various occupations.

Weather stations work with the United States Weather Bureau to forecast weather.

Physics

Machines—how they help us do our work.

Anything which helps to make our work easier and requires less force to do the work is a type of machine.

Some simple machines are: wheel and axle, pulley, lever, and inclined plane.

Some kind of force is needed to make all machines work.

Oil and grease are necessary to prevent friction in a machine and keep it working smoothly.

Heat—how heat changes materials.

Heat causes liquids, solids, and gases to expand.

Cold causes liquids, solids, and gases to contract.

Liquids boil at sufficiently high and freeze at sufficiently low temperatures.

Water boils at 212°F. and freezes at 32°F.

Magnets and Compass.

Every magnet has a north and a south pole.

Like poles of a magnet repel each other.

Unlike poles of a magnet attract each other.

A field of force reaches out for some distance around the poles of a magnet.

The earth is a huge magnet and has a north magnetic pole and a south magnetic pole.

Magnets are of great help in lifting heavy steel objects.

A compass points to the north or south magnetic poles.

A compass is an aid in finding directions.

The facts and principles of science are all-pervasive in any community; but it is impossible, except authoritatively, to assign any exact order in which they are to be learned. The development of the scientific attitude should be approached as the development of any skill such as reading or spelling is approached, proceeding from definable simple steps to the more complex whole. Facts and principles of science also are approached from simple beginnings to a gradually expanding understanding of the whole field of science, but environments and interests of children are too diverse for anyone to be able to say exactly when a fact or a generalization will arise.

It is, however, possible to make suggestions for a planned course and to incorporate those suggestions in books that teachers and children may use effectively. Knowledge of the way children learn, of children's interests and of the areas of science in which children are likely to be interested and which they can understand and use is the basis for such suggestions.

Children learn by doing. That means of course that mere memorization of facts is relatively unimportant, except for the person who has decided upon some area of science for specialization. Through activities the child makes use of the facts of science and begins to learn them. Children learn by using and extending what they know in many and varied situations.

Children are interested in their own affairs at home, at school and in all kinds of situations. They are interested in animals, in toys, in making things, in reading, in discussions with people who know, in observing and exploring, in finding their place in a social setting. The list of items which interest them can be extended indefinitely and individually for any child.

The areas of science in which children at different levels of development and on different levels of understanding are likely to be interested and which they can use are: pets and other animals, weather and seasons, earth and soil, stars and the sky, gardens and farms, plants and food, themselves and their bodies, health, safety, conservation, machines and toys, magnetism and electricity, light and sound, energy and force, man's efforts to control his environment, inventions and discoveries, growth of plants and animals, adaptation and survival, air, water, chemicals, diet, reproduction, and the social life of the world about them generally. At the end of a program of science, general acquaintance with common aspects of all those areas might be expected.

Anyone who is planning a course in science for a particular year must necessarily take into account past learnings and look forward to additional learnings. Since the facts and generalizations in science do not require presentation in any exact order as skills do, no harm can come to a child in preparation for further study if particular areas of facts and generalizations in science are unknown. That is to say, most children can live

happily and successfully without knowing, for example, that seeds travel in various ways, that electric currents are produced by moving a wire through lines of force, that magnets pick up substances made of iron or steel, or that rays of light travel in straight lines. To say that, however, is no argument against a definite program of science in the elementary school. Science is all around, and understanding it adds mental stature, helps get rid of superstition, contributes to a feeling of security, and increases interests. It follows from the above statements that planning science learnings in larger blocks such as primary school, intermediate school, junior high school or even whole elementary school is justifiable. It is often done that way in courses of study and by such experts as Craig and Blough.

In order to be of service to the teacher of different levels in years of school growth, the following suggestions for science in each of the years in elementary school are given. The method used by the teacher in presenting the subject matter will properly be varied. Some of it will be tied up with increasing understanding of incidental happenings with significance for science. Some of it will come in connection with making school activities, such as eating in the cafeteria and going to the school health room, more meaningful. Some method will take into account science learnings that come from developing units of work and large topics of study or from study of other content areas, such as geography and literature. Much of it will be tied up with reading in books that tell of aspects of science. Method will involve experimenting, observing, interviewing and constructing. It will not properly consist of merely memorizing facts and generalizations.

All that has been said previously in this book or that will follow in its later sections or that can be learned from consulting other books on the teaching of science in the elementary school or teachers' manuals that accompany planned courses and suggestions in courses of study should be used in interpreting and adapting to individual situations the plans which follow.

The First Year

All children in the first six years of life make collections of one kind or another, have had experiences with pets and toys, and

have come in contact with conditions of change in the weather. In the first year of school, extensions of those experiences would make use of the child's readiness for science and increase his learning. Observing collections, identifying items of general interest, making trips to add to collections and using eyes, ears and the other senses not only are early steps in developing the scientific method but also lead to acquisition of facts and to formulation of simple generalizations. Keeping and caring for a pet in the classroom or talking about pets at home or in the community should be a part of the planned program. An aquarium of a simple kind, merely a container with one or two fish and a plant or two, is essential. Keeping weather charts brings awareness of changes in weather conditions, differences in weather at different seasons and even times of day, and need for proper clothing. Every first-year classroom should show that weather charts are being kept or have been kept. How greatly those three activities—making collections, keeping and caring for pets and keeping records of weather—will be extended is a matter of choice and of possibilities.

In every first year of school, children should have the experience of seeing plants grow from seeds and of realizing the need for caring for plants. Plants may be put in window boxes, in pots or in a small school garden. And in the first year of school children should have a wagon, a hammer, and a saw with which to work. The extent to which toys and tools and other mechanical devices can and will be used is equally a matter of choice, as is the making of gardens.

The apparatus needed for the first year of science is easily obtained. Pots of various sizes, drinking glasses or clear glass jars, pans or dishes for holding water, a pitcher, hammer, saw, nails, wood, paper, and a thermometer would be needed. A magnet, either bar or horseshoe, and a prism should be provided for individual experimentation. As many simple experiments as possible should be performed if they help answer real questions that children have. These are some that could be performed easily and that would help to understand conditions of the weather, growth of plants and the work which men do: A glass pushed upside down into water shows that the glass is not really

empty; if some plants are watered and others are not (provided all other conditions are the same), the conclusion can be drawn that plants need water for growth; if some plants are kept in the dark and others are kept in sunshine (provided all other conditions are the same), the conclusion that plants need sunshine to stay green will follow; a cloud may be made by boiling water and watching the vapor change; a pinwheel will show the effect of moving air; a seesaw may be used to show how balance is secured; a magnet may be used to determine what kinds of objects will be picked up by it. The list might be extended and still be kept within the level of understanding of children in their first year of science. Conclusions should never be drawn from one experiment. It is a part of scientific method, which should be begun in the first year of the program, that scientists check themselves by performing experiments many times to be sure of results. Children should perform the experiments for themselves, but under careful supervision.

The subject matter of science in the first year, taking into account the age of the child, his probable interests and the contribution which it can make to his growth in understanding his environment, should include at least these areas, remembering that growth in scientific attitudes is a part of the subject matter; using the senses, experimenting, reading and asking questions as ways to find out; changes in weather conditions and wearing proper clothes to meet them; change from day to night and observations of the sky at different times of day and night; differences in the forms of bodies of land and of water; plants and their growth from seeds and their need for water, food and sunshine; pets and other kinds of animals and how to take care of them so that they grow healthy and strong; the use of tools to help make work easier.

The learning of specific facts in any of the areas is relatively unimportant, although many facts will and doubtless should be learned. Generalizations which grow from the facts that are encountered and perhaps learned are an essential part of the science program. Generalizations are broad inferences drawn from facts which have been observed or learned through reading, listening, or experimenting. They should not be drawn

from a single observation, experiment or experience. During the first year of science in the elementary school, generalizations of much depth cannot be made. The children will have had too few experiences for reaching comprehensive conclusions. It is possible, however, that the following simple generalizations can be stated by children in their own words: Weather is not the same every day; different kinds of clothes are worn on different kinds of days; pets need good care; children need the right kind of care for proper growth; animals are not all alike; plants are not all alike; seeds may grow into plants; plants need water and sunshine; sometimes clouds hide the sun, the moon or the stars; the sun makes the day; shadows change with the time of day; the moon does not appear the same every night; land is sometimes smooth and sometimes rough; farms and gardens have soil; most plants grow in soil; sometimes air is moving and sometimes it is not; wind is air that is moving; air and wind cannot be seen; tools help people do work; men make tools to help them work; there are many kinds of tools.

The Second Year

Children often take trips to find out about something that interests them or merely to increase their experience. The guide for the trip may be a parent, a teacher or any more informed leader. Trips may be used to add to the child's progress in developing the scientific attitude. In their second year of a science program, children are able to help make plans which are more organized than those they help make during their first school year. If a plan for trips is carefully guided, it not only adds a step in developing scientific attitudes, but it also becomes a tool—a skill so to say—which can be used continuously in many school and home activities. The plan would follow these general headings: What we want to find out; What to look for; Where to go to find our answer; How to go and how to be safe; What to take on the trip; What to bring back from the trip; and finally What we found out. No one can say just what any given group of children will want to find out, but the pattern once established and followed consistently will be the pattern which scientists consistently follow.

Most children like to experiment. They do it at home and at school. In their second year they can help make a plan for experimenting. This is a pattern which the teacher can help them discover. General headings would be: What we want to find out; What apparatus we need; How we used the apparatus; and finally What we found out by our experiment. This is essentially the same procedure that was developed in the plan for taking trips and it is equally the plan which scientists follow in finding out what they want to know.

Considering the possible interests of children, their level of development and the large areas of science which may be explored, the following aspects of science should probably be included. First of all are plants and animals. In autumn seeds are everywhere and it is likely that many will be brought into the classroom and more can be collected. The question of how plants grow is within the comprehension of children and interests most of them. Trips to farms, observations of plants in pots and

In the second year of a program of science, children's interest in pets and other animals should be developed enough for them to assume responsibilities.

Jordan School District, Sandy, Utah

window boxes, and talk about food will lead to inclusion in the planned program of how seeds travel, the parts of plants, seeds that are used for food and how plants grow from seeds. This leads naturally into questions about how plants change from seeds to plants and to seeds again, how animals grow and change, and how children themselves grow and change. The simple fact that some animals grow from eggs and some come from the mothers is easy to understand. Many observations, and some experiments such as watching seeds as they begin growth, frog or toad eggs as they change into tadpoles and then into frogs or toads, and a cocoon or chrysalis as the moth or butterfly emerges and the eggs of insects as they change into caterpillars and cocoons again can be carried on simply and with great profit to a program of understanding growth and change in plants and animals. That is a beginning in understanding the cycle of life. The question of what plants, children and other animals need in order to grow from babyhood to larger plants and animals will lead into discussions of food, water, sunshine and stages of change. All these items should be kept on the child's level, and the teacher must accept the responsibility for deciding upon the level of development not only of the whole group of children, but of individuals within the group. Help in making that decision can be obtained by consulting books that are designed to present subject matter in science for the child in his second school-year.

All children can be helped to become more careful observers. An aquarium in the classroom is an essential. It should be large enough to accommodate several kinds of plants and some snails. Experiments in evaporation of water from a dish and the effect of heat on evaporation, in showing that air is in water, in showing how a siphon works when cleaning trash from an aquarium introduce the topics of air, heat and water. If a bird bath and a bird feeding station can be arranged for observation at close range, the effect of change of seasons on bird life will be introduced. If a bird house or the nests of birds can be observed closely, the whole question of what homes animals make will be brought up. Many facts about different kinds of animals will be relevant to the discussions which follow the observations. Seasons of the

year and changes in them can be made into a major topic that will keep recurring throughout the year as observations continue.

The wind and sky are interesting to children and should be a part of the planned program for this year. Experiments to show the effect of heat on air should be extended to explain how warm air rises and how wind is made. Thermometers, wind vanes and the movement of kites should be examined. Changes in the sky as a result of clouds, rainbows, and the positions and appearances of sun, moon and stars should be noted. A prism can be used to show how white light is divided into colors. The experiment to show how water vapor is changed into a cloud should be performed again. An emphasis upon changes in wind, weather, seasons, sky, and time would be natural.

Simple machines such as the seesaw, levers, scales of different kinds, wagons, wheels, and pulleys can be explained and should be, for small children want to know about them since they use them or see them in use constantly. It is not the mechanical principle of the machine that interests the child at this period of growth but the way in which the machine is used to help work. Children know about many machines such as automobiles, lawnmowers, sewing machines, motors, tractors, and locomotives. The use of steam, gasoline, and electricity to make machines work can be the subject of many fruitful discussions. Simple toys often show how springs, electric currents, and principles of balance are used to make the toys work. Mechanical toys should be brought and explored in a general way. It is sufficient if children become curious about them. The mechanical principles would be beyond the children of this year, although making an electromagnet, simple spool tops and pinwheels, or water wheels would not. Children like machinery, and the questions they have can usually be answered. Some children at this age merely want to operate the machine or toy and would not have many questions to ask.

Light and sound are areas that can be included in the program. A magnifying glass, mirrors and a prism show that light from the sun can be used to burn paper, that rays of light can be divided into colors. Protection of eyes and ears and other measures of safety should be stressed.

Many facts will naturally be learned. What they should be cannot be decided definitely by anyone but the child who learns them. Children who have rich experiences with science will want to learn some facts, and if those facts are related to plants, animals, children themselves, seasons, earth and sky, water and air, change and growth, tools and machines, sources of power such as electricity and steam, and safety, the planned program justifies itself.

Generalizations related to rich experiences should be expected. The following are among those that children in their second school-year may be expected to state in their own words: Seeds travel in different ways; plants have different parts; seeds determine the kind of plant that will grow from them; plants grow and change; animals grow and change; children grow and change; seasons are not all alike; different animals make different kinds of homes; air moves in different directions at different times; many changes are taking place all the time; machines are made to do work in many ways; light, heat and sound may be useful, and they may be harmful; precautions for safety can be taken; observations can be made carefully; there are many ways to find out what you want to know.

Apparatus needed for the second year of science is: a straight-sided aquarium, straight glass tube, rubber tubing, candles, lamp chimney, thermometer, spring scales, dry cell, electric switch, copper wire, pulley, wagon, prism, small mirror, drinking glass, blotter, paper, wood, rulers, flat plates or pans, pitcher, matches, saucer, string. Most of the items can be brought from home or salvaged.

The Third Year

Science is all around at home and at school, in the city and in the country—in every kind of community. One needs but to sit still and look and listen to become aware of it if only a few facts of science are known. An obvious place to explore science in an environment is a classroom. Even a classroom having bare essentials such as desks, blackboard, pencils, erasers, paper, textbooks, crayon, light, heat, children, clothes, and the room itself is a mine of treasure for use in a program of science. If the

classroom is equipped with aquarium, growing plants, pencil sharpener, modern heating and lighting devices, workbench, and tools, paste, electric outlets, running water, phonograph, tuning fork, electric hot plate, easels, paints, woods, clay, paste, globe and books of science for reference; and if it is in a school where commercial audio-visual aids such as television, moving picture machine, musical instruments, laboratories, projector, space for gardening, gymnasium, thermostatic controls, light switches, and all the marvelous new equipment and supplies are available, it has practically the whole world of science available for use. Awareness of the world of science which surrounds them is probably the greatest asset which can be given to a group of children. From awareness comes the desire to know why and how. A scientific attitude is the desire to know, to understand. In the third year of the planned program of science, a major aim of the teacher and other curriculum-planners should be stimulation of curiosity about the world of science and satisfaction of curiosity in areas in which children display special interest. This would be the time to begin to learn about how some famous scientists have satisfied their curiosity. It is the time to begin in a determined manner to break down superstitions. By the end of the primary school years at least, it may be expected that children will be ready to launch out into more specialized areas of learning, and they will not do that unless they have become curious.

Helping children to solve their own problems is one of the major aims of education today. It is also one of the most difficult to achieve. Effective teaching of science contributes greatly to the accomplishment of this aim by developing in children wholesome habits of satisfying curiosity, of acquiring firsthand information, of making careful observations, of utilizing all available sources, of respecting the opinions of others and of delaying conclusions until sufficient data have been collected and evaluated.

The areas of science in which curiosity could be aroused by exploring the well-equipped and supplied classroom are heat and light, sound, electricity, machines, modern inventions, tools, air and weather, plants and animals, children, chemicals, substances

of many kinds, safety, conservation of supplies and health, and power and energy. One part of the planned program in this third year should be given to discussions of evidences of science in the classroom and school, to lists of questions for more investigation and to equipping the classroom so that it becomes a workshop for understanding science as well as other subject matter.

Subject matter related to living things, stimulated by the aquarium, a terrarium, pets at home, a pet at school, plants grown to take home or in other ways, would be likely to follow curiosity about how plants reproduce themselves, how baby animals sometimes come from eggs and sometimes from mothers, how living things move, what are the differences among plants and among animals, how some plants and some animals are useful and some are harmful, and why some plants and animals should be especially protected. Children should perform more experiments to show that plants grow from seeds and how they grow, and that plants need water, food and sunshine. They should find out by experiments that plants do turn toward the sunlight and that all living things move at least parts of themselves. They should look at microscopic animals under a microscope if possible and note division into two animals of the same kind from one single animal. They should observe plants and animals in a garden or in some selected place, making lists of harmful and useful ones, and of different kinds of plants and of animals, examining many animals closely and keeping notebooks of science in which are recorded facts and incidents that have particular interest for the one who is doing the writing. The end of the work with plants and animals should lead to statements about how living things are distinguished from things not alive.

The topic of non-living things should be given equal coverage with living things. It will take its beginning from explorations in the classroom. It should be extended into the home. The kitchen is a place where non-living things are especially in evidence. Steam, heat, electricity, ice, water, machines such as egg beaters, cooking utensils, thermometers, and many other items should become the subject of discussion, experimentation and investigation.

Since the questions that children may have offer all manner of opportunities to learn science and since the questions cannot be determined in advance and will vary with individuals, about the most that can be expected in the planned course in science is to pose some questions in advance, expose children to them and invite each child to keep his own notebook of science, posing to himself the questions he has and seeking and recording answers. Looking at the special emphasis that has been placed on contrasts between living and non-living things and taking a cue for the questions that will be planned in advance, the teacher or other curriculum-makers could use some such questions as the following: How can we protect birds? How are we like frogs? How are we like birds? In what substances that we use in kitchen utensils does heat travel fast? How is sand made? Is a rock alive and how can we know? Why should a farmer not let his soil remain bare even in winter? Why is the ocean becoming more salty? The list could be endlessly extended, and it makes no great difference what the question or the area of interest which a child has. The main point to be sure of is that he is curious about something that leads into an understanding of the environment. Many books can be used, when once the children have mastered the skill of reading, as many have been used, in the third year of school, to stimulate curiosity and to satisfy it.

Inventions that have been made to help satisfy curiosity should be observed, and experiments that help explain their use should be performed. Balance scales, thermometer, wind vane, microscope, magnifying glass, telescope, field glasses, compass, and others often would be available. Checks upon how well children use the facts of science which they know should appear near the end of the program of science in the elementary school.

Children in the third year of school have curiosity to know for the sake of knowing as well as for the sake of solving problems. In the course that is planned for them one or more special areas of subject matter that is interesting for its own sake should be explored. Possible areas that might be selected are: How soil is made; plants in the world of science; animals in the world of science; machines and machinery. If any of the areas are covered in this year of instruction in science, other teachers should be

notified so that the same areas will not be duplicated in other years of instruction in science.

The one who plans the program in science in the third year may make a list of generalizations which pupils should be able to make at the end of that year, but an even more important contribution would be to examine Craig's list, or a list from a course of study, of generalizations for the primary grades and check upon those that have been covered by the materials, subject matter and activities in the first three years. This might be such a list:

Plants and animals are living things.
Some plants and some animals are useful, and some are harmful to man.
Seeds travel in different ways.
Plants and animals require food and care.
Living things change with the seasons.
The weather is not the same every day.
The sun is important to life.
Air is all about us.
Living things make more living things.
Seasons come and go.
The earth is made of air, land and water.
Some wild life needs care and protection.
Men have invented machines to make work easier.
Friction may be useful or it may be harmful.
Paint is used to protect wood and iron.
Magnets will pick up some objects.
Animals depend on plants or other animals for food.
Mammals are a special division of animals.
No two living things are exactly alike.
Heat travels faster in some substances than in others.
Man gets food from plants and animals.
New plants are formed from old plants by seeds, runners, bulbs, cuttings or in other ways.
Some baby animals come from eggs, and some are born alive from their mothers.
Human bodies are like machines in some ways.
Air is necessary for burning to take place.
Scientists do not believe anything without proof.

At the end of the third year, children should know many facts related to these areas of science: How to find out, pets, farm

animals, different kinds of animals, inventions, water, air and wind, heat, light, electricity, growth and change, seeds, useful plants, useful animals, harmful plants, harmful animals, weather, birds, an aquarium and how to care for it, how to be careful, machines, food, friction, day and night, the sun, the moon, land and soil.

The Fourth Year

In planning a program of science for the fourth year, two special aspects of child growth and development should be considered and added to aspects related to interest and level of development. The two aspects that begin to show more significantly as the child approaches the intermediate school years are that the social significance of science emerges as of more consequence to the child himself and the group of children and that children are increasingly more interested in special areas of subject matter in science merely for the sake of knowing the facts.

In the fourth year larger units of study, or units of work, are often undertaken, for example, the study of homes, clothing, food, ways of travel or weather. These often are comprehensive studies making use of many areas of subject matter and of skills in many fields of study. They give science its rightful place as a contributor to improving ways of living. If the children had undertaken a study of homes because of trips to see a home in process of construction, of collections of pictures of homes of different kinds, or of reading about homes, these are areas of science which should be included at this level: Materials for building houses; ways of lighting houses; ways of heating houses; water for houses; and inventions that make living in houses more pleasant. Progress in each of the areas from earliest time to the present would interest most of the children. Homes of men and of other animals would be compared. Experiments, experiences, and illustrations of many kinds would be used to show the making of candles; need for air in burning; arrangement of lamp chimneys to provide air; oil, gas and electricity as sources for light and heat; measurement of amount of light; circulation of air and water at different temperatures; air and water pressure; and many other facts and principles. Brief biographies of Edison,

Bell, or Marconi should be read and discussed for the contribution of scientists to the improvement of living.

During a study of food, an intensive study of a particular area in science probably would arise. Many children want to know about chemicals. It is important that they should, and so the planned course would contain information that all substances are made of chemicals. A short study of chemicals would bring out other basic facts. A few simple experiments should be enough to satisfy all but the most curious and determined children, and they could be directed to books on their level of reading ability for additional information.

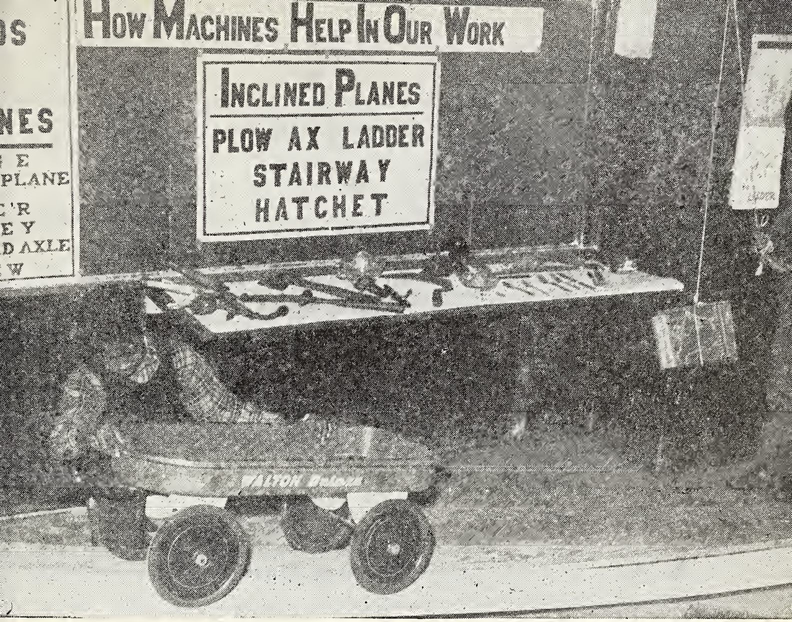
A study of foods is important after the children have had some experiences with choosing food in a cafeteria or helping to prepare meals at home or at school. It should include an experiment in feeding rats, hamsters, or mice. It should include choosing the right kind of diet because that would supply information about foods that produce growth, energy and health. A simple presentation of facts about how our bodies take chemicals from food, air, and water and how other animals and plants do it too should be given. The work of Louis Pasteur in discovering bacteria and how to control their growth should be in the planned program for the fourth year if the study of food is made in that year. The study of food should certainly be undertaken in one of the intermediate school years. Children should prepare and cook foods for parties and lunches and should be helped to keep individual health records.

Comparisons of the homes and food of human beings with other communities of living things should be included in the program for this year. Children should set up well-planned aquariums and terrariums and choose special places for continuous observation at all seasons of the school year. Illustrated oral or written reports upon flowers, birds, grasses, pests, insects, harmful plants and animals, useful plants and animals, and changes in the communities that are observed over periods of time should be especially important to the members of the class. An understanding of change and balance among living things should be secured. That would involve how plants and animals are interdependent and how they are protected.

Some facts about the earth and sky should be included in each year of the elementary-school program of science. Establish the fact that the earth is round and that it turns toward the east. Help the children begin to understand revolution and rotation. Help them place the earth as one of the planets of the sun in our solar system. The concept of the universe should be presented for discussion. Chief constellations should be located. Help the boys and girls understand the pull of gravity and what is meant by water seeking its level. Some ideas of distances between earth and moon and earth and sun should be gained. A study of how the soil on the earth is made and of how erosion can be controlled would be a natural follow-up of discussions of gravity, water level and the earth as part of the universe. A small amount of information about how scientists have come to know the age of the earth should be given, and an intensive study of minerals and rocks would interest many of the boys and girls. Identification of some of the common minerals, as of some common birds, trees, grasses, wild flowers, pests and insects, should be encouraged although merely knowing the name of anything is only a small part of instruction in science.

In every year of school, children will learn something about weather, but in this fourth year or later is the place for a comprehensive study of weather. Weather reports should be collected, instruments that have been invented for use in predicting the weather should be examined and perhaps made, and the value of weather reports to different occupational groups made clear. Clouds, rain and the water cycle should be explained by experiments, constructions, observations, illustrations, and reading matter. Storms, thunder, and lightning should be explained. Many easy experiments in producing static electricity by friction should be performed to lead to an understanding of lightning. Help the children understand the difference between weather and climate.

Since children are interested in airplanes and since some accumulation of understanding about how machines work should be expected in each year, a study of ways of travel should be included. Children are also interested in ways of communication through radio and television and in many other aspects of science



Louisville Public Schools, Louisville, Ky.

A study of the inclined plane and other simple machines would have many practical applications for children—especially boys—in the fourth year of science.

as used to make living more pleasant, comfortable or safe. Which aspect shall be chosen for inclusion in any of the intermediate years in school is a matter for the teacher and other makers of planned courses to decide. Whatever the decision may be, study of the aspect which is chosen should include something of its development from long ago to now, reports and discussions of work of some scientists who have made inventions or discoveries in the field, experimentation to lead to an understanding of facts and principles that underlie the particular aspect of science under discussion, and the relationships of science in that particular area to social improvement.

Facts and principles for the year should cluster about these areas of science: plants and animals, food and health, balance and change, inventions and discoveries, light and heat, sound, machines, electricity, chemicals, energy, safety and conservation. That seems all-inclusive and so it should be. As children look

about them with curiosity, they find that they are surrounded almost at any moment, certainly within the period of an hour or two, by all aspects of science.

The facts and principles which belong to the different areas just named call for their special generalizations, usually generalizations which have already been begun and are now enlarged by new facts. Each year of school should increase the depth and the number of generalizations. A composite list of some generalizations that should probably be expected by the end of the sixth school-year is given on pages 194–195. The fourth school-year should furnish its due share of growth in formulating them, but it is impossible to be so exact as to specify just what special bit each year should be expected to supply. The teachers will have to cooperate to insure coverage and avoid overlapping.

The Fifth Year

As the teacher or other curriculum-maker begins to plan for the last two years of the intermediate school, it becomes necessary to look back at what has already been planned for earlier years and forward to shortcomings that exist. Questions begin to arise as to what more should be encompassed if aspects of The Universe, The Earth, Conditions Necessary to Life, Living Things, Physical and Chemical Phenomena, and Man's Attempt to Control His Environment are to be explored as far as children in the first six years of school can understand them.

Many experiments and experiences have brought general understanding of magnetism and the uses of electric currents. These should be repeated and others used to help children understand how current electricity is made. A rather complete review of magnetism and extension of an understanding of the principles underlying current electricity would interest boys and girls in the fifth year of the program in science. This lends itself to being organized as a rather formal presentation of one aspect of science. Experiments to show action of magnets, use of the compass, fields of force, static electric charges caused by friction, current electricity from chemical action and from cutting lines of force, short circuits and uses of electricity should be performed. Practical applications can be secured by lighting a

miniature city or a doll house, making a telegraph sender, magnetizing a steel rod, and engaging in other activities where electricity and the principles of magnetism are employed.

Not much has been learned before this year about chemical changes. Although many teachers have not had formal courses in chemistry, there is a large body of information about chemistry that lies easily within the grasp of anyone who wants to understand the world. Invisible inks, rust, bubbles from baking soda, putting out fire by chemicals, burning substances, tests for starch, and colors made by chemicals are all interesting to boys and girls, easy to explain by experiments, and profitable to the program of science. Many chemical changes take place in the body when air is used and when food is digested. Experiments to show what happens to air after it has been taken into the lungs and to show how air is inhaled and exhaled can be performed by children in the fifth year or even earlier, as can experiments to show the chemical effect on food of churning by the stomach and of mixing food with juices such as saliva. How light affects the chemicals on sensitive paper used in photography is easy to demonstrate.

Vibrations in substances have been noted by children many times and perhaps rather thoroughly explained. In this fifth year the subject should be re-explored and related to the ear. How sound travels and what makes sound can be seen if a simple tin-can telephone is made. The subject of light can be re-explored and related to the eye. Work with a pinhole camera and with making blueprints will show much about how light travels and how images are formed. Illustrations of the ear and of the eye should lead to discussion of ways of protecting them.

Learning about living organisms has been included in each year of the planned course. In this fifth year special emphasis should be placed upon how plants and animals grow and upon conditions that cause differences in plants and animals. Pollen grains, sperm cells, egg sacs, and the embryos of both plants and animals should be explained simply and naturally because early understanding of the subject of reproduction is important to boys and girls. Much about reproduction has already been placed in the earlier years of the planned science course, and the

accumulated experiences and learnings should be recalled. The work of Luther Burbank in producing new varieties of plants should be studied. New varieties of animals such as dogs, cattle, and chickens and how they have been produced should be one of the topics for this year. A study of cells should form a part of this section of the year's work related to living organisms.

How raw materials are changed into finished products is a topic that is socially significant and that interests boys and girls of any age level. Something of this has been included in earlier years, but only desirable overlappings would appear if units of work or extended study should be made of any industry important to the community or to social living. Suggested industries are flour and cereals, oil, coal, lumber, dairy products, cotton, fruits and vegetables, peanuts and candies, iron and steel, eggs and chickens, and a host of others. Whatever ones are selected for this year should include study of the raw material, machines and workers that help make changes in the material, and the finished products. The work of any scientist who has contributed to the process of changing the raw material into finished products should be studied; Eli Whitney for cotton and George Washington Carver for peanuts, for example. Each teacher and class will probably have personal choices, and reference books, trips, collections, interviews, audio-visual aids, experiments, and activities of many kinds will be used to explore any choice of industry which is made. This study of changing raw materials into finished products should lead into a study of the principles by which machines work. Such a study of mechanical principles might be subject matter organized in a formal way as it might be in a course in physics in high school or college. It would include experiences with levers, inclined planes, wedges, screws, wheels and axles, pulleys of all kinds, friction and ball-bearings.

Another aspect of science which has been approached in earlier years but which deserves a rather complete exploration is the age of the earth. This should be approached from fossil remains and rock formations. It is a subject that can be omitted entirely or extended greatly according to preferences of the class. Individuals in any class are likely to be much interested in such a

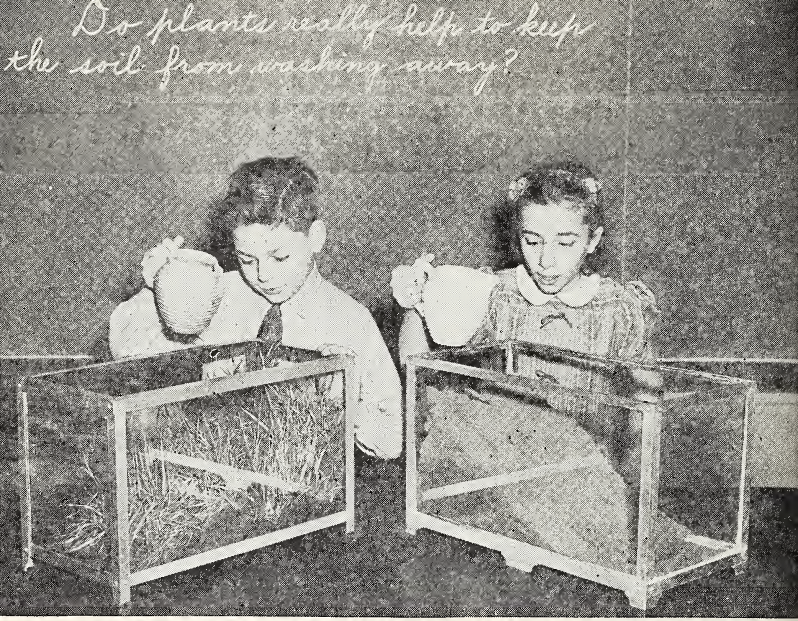
topic. They could report to the whole class. At least some talk about the topic should find a place in this fifth year of work in science. Many pictures may be assembled to stir interest in a topic that is often in the newspapers and magazines.

The Sixth Year

During the sixth year of a planned course in science, additional facts should be learned in areas that have not been adequately explored, and a synthesis of the six-years program should be achieved. "Adequately" means that boys and girls have gotten, from the different aspects that have been explored, as much science information and method as they can assimilate meaningfully and usefully into improvement or enrichment of social living. Learning facts of science should not be done merely to satisfy the planner of a course but to satisfy the curiosity or to help solve the problems of the learner. Aspects of science that have not been adequately explored as one examines the course as planned herewith are the human body as a machine, preserving health, conservation of resources, the cause of seasons, changes on the earth, survival of plants and animals, and modern inventions.

The human body has parts—skeleton, muscles and joints, lungs, heart, stomach and intestines, skin, nerves and brain, and other organs—that help it to perform the actions of a machine and to direct itself. Learning in this area would be a much curtailed study of physiology. Posture, body cells, protective devices, food, and general rules for health would be a part of the study.

A unit of work should be made of the conservation of farmland, garden soil, soil, water, wild flowers, plants that supply food, trees, birds, fur-bearing animals, farm animals, materials, machines and tools, heat, energy, buildings, roads, fuels, clothes, food, the human body, and all other areas in which conservation, or wise use, of resources is important. The many modern devices and procedures that have made conservation possible should be included in the unit of work, even though much emphasis has already been given to the need for conservation. This year should bring to the program a complete exploration of the topic with



Cleveland Public Schools

The importance of conservation can be brought home to urban and rural boys and girls alike through an effective demonstration.

as many practical applications and as many stimulating and informative observations as possible.

The inclination of the earth's axis as a cause of changes in seasons is probably within the understanding of students in their sixth year of work in science, and along with it studies of latitude, zones, and altitude would be equally appropriate and possible. Longitude and time belts might be included, but they are social and political conveniences and may be safely omitted for later study. The study of the causes of changes in seasons should bring in a complete review of previous learnings about rotation, day and night, shape of the earth, the solar system, motions of the earth and the moon and of the earth and the sun, and changes which plants and animals (including people) make to meet changes in seasons.

Changes in plants and animals and in the surface of the earth have been explored earlier but should be expanded in the sixth year to include changes made by man in producing new varieties

of plants and animals and in fitting the surface of the earth to his needs, and changes made by air and water through motion due to differences in heat and to the pull of gravity, by underground water and its action due to chemicals, by volcanoes and earthquakes, by glaciers, by heat and by the pull of gravity on the substances of the earth's surface. The topic of change should be a major area of study in this year, and it will lead into study of how plants and animals have been able to survive those changes.

If transportation and communication are developed as units of work in the full meaning of that term, many modern inventions will be examined, used and studied. A few of the many that suggest themselves are airplane, jet-propelled engine, bridge, turbine, truck, highway, tunnel, radar, television, phonograph, telephone, radio, telegraph, motion picture, print. Many facts of science related to motion, force, friction, vibration and electromagnetic waves should be explained by the use of experiments and diagrams. Weather, health, safety, housing, and conservation might be developed in the same way. In both transportation and communication, safety should be an integral part of the unit of work, even if it has been itself the theme for a unit of work, or large topic. In making studies in which modern inventions have prominent places, time should be taken to make careful reports upon the inventors and the principles of science which they employed in making their invention. By the end of the planned course the work of at least the following scientists, both their method of work and their accomplishments, should be known in some detail: Francis Bacon, Louis Pasteur, Thomas Edison, Alexander Graham Bell, Samuel F. B. Morse, Luther Burbank, Guglielmo Marconi, Galileo Galilei, Joseph Lister. Many others should be added to suit the particular areas under investigation.

Two aspects of science should receive special consideration in this sixth year of the elementary school program of science. They are: first, the omnipresence of science in any community; and second, the part that magic and superstition have played in man's effort to control his environment. A survey of the community should be a part of this year of science as observations of particular parts of the community have been throughout the

six years. Many opportunities for identification of plants, animals and articles in the community will arise in connection with the survey. Many contributions of science to improved ways of living will be noted. Many facts of science will be assembled and used to show how the community can extend its measures for improvement. This is the best of all ways to help boys and girls recognize the contributions which science has made to their lives and living in their community. A study of magic and superstitions will test, as nothing else will, the extent to which members of a class are prepared to use the scientific method. Local superstitions and sayings about weather should be collected and some of them subjected to proof. Experiments that would once have been called magic should be performed and explained. A short study of eclipses of moon and sun would belong either here or in the study of motions of the earth, moon, and sun.

Craig lists (pp. 528–550, *Science for the Elementary-School Teacher*) approximately four hundred generalizations that might result from a program of science covering the first six years of the elementary school. It is an excellent list which the ones who develop a planned course to cover the six years should use as a measuring stick in evaluating results. No one child would be expected to be able to state all the generalizations or even to have had experiences that would lead toward them all. It is conceivable, however, that many children, who have carried on a forthright program and have been active in using what they have learned, could do so, or at least would understand what was meant if another person made the generalization.

Here is a list of comprehensive generalizations that most children after having carried on the planned program that is given in this chapter might be expected to make at the end of the sixth school year. The list, of course, can be expanded greatly.

Scientists check their conclusions carefully.
Gravity pulls everything toward the center of the earth.
All substances are composed of chemicals.
Conditions of the weather affect life on the earth.
Climate is influenced by many factors.
Living organisms grow and change.
Many special developments protect plants and animals.

Some living organisms have been able to adjust to changes and have produced others like themselves and have survived.
All life as it is now known comes from other life.
Living organisms are made of one or more cells.
Only green plants make food.
The sun supplies the living things on the earth with heat.
Sound is made by vibrations in substances.
Chemical elements can be arranged in new ways to produce compounds.
All substances are composed of molecules.
Conservation of resources is a common problem for all people.
Plants and animals are interdependent.
The universe is vast.
New ideas are being used daily to improve ways of living.
A balanced diet is necessary for good health.
There are many sources of energy.

The Seventh and Eighth School-Years

The principles and practices of science instruction described earlier are generally applicable to school years seven and eight. The two most important factors to be considered in giving special attention to these years are the characteristics and needs of children of this age and differences in school organization.

There are a large number of schools in the United States organized on the 8-4 plan, although in many places, the eight-year elementary-school organization is considered to be at odds with our knowledge of the development of children and youth. The six-year elementary-school organization has grown until it enjoys a steadily increasing majority. Although it is currently in favor for ostensibly good reasons, one can only conclude that the final solution of properly educating children will be found in the individual pupil-teacher relationship. Organization may facilitate the teacher's work, but it does not offer a solution to many of the problems of learning.

Instruction in the seventh and eighth school-years may well be organized to facilitate the broad-fields type of curriculum. The school day is at the present time most commonly organized on the basis of single subjects taught by separate teachers. The broad-fields curriculum organization offers a desirable transition from the single-teacher experience curriculum of the first six

school years to the departmentalized organization of the typical secondary school. This compromise retains the economy of departmentalization and achieves some of the advantages of the experience-curriculum organization.

Characteristics of pre-adolescents and adolescents have been presented in detail in so many volumes that it does not seem worthwhile to enumerate them here. The more important aspects of this growth may be summarized as follows: Muscular growth is very rapid, and if the proportion of this growth to the growth of the body framework is out of balance, it may result in poor control, which may be misinterpreted as deliberate awkwardness. Children of this age are strongly individual. Competition is keen. It is easy for children to engage in too many activities and become fatigued, which will frequently result in strained relationships. The approval of the peer group is more important than the approval of adults. There is a strong interest in sex. There is some interest in money-making activities. The child may be overanxious about his own health, and he is apt to have a ravenous, although sometimes capricious, appetite. An increase in desire to improve personal appearance provides an excellent opportunity to remedy defects in posture and to establish a balanced diet. There is a development of interest in more abstract and mature concepts, and particularly, there seems to be an increase in the desire to learn more about science.

Science education for the 12-, 13-, and 14-year-old will be effective if it draws upon the understanding of an age group as a source of suggestions as to what to teach and plans educational efforts in terms of the interests, capacities, and skills of this age group. It is necessary that the teacher be cognizant of individual differences, both intrinsic and extrinsic. Environmental differences, brought about by specialization of interests resulting in specialized experiences, may be influential in producing differential growth of various abilities. These will be carefully evaluated by the effective teacher. The teacher who wishes to capitalize upon the interests of students should, at the start, adjust the program to the present interest level and should be alert to the possibilities of eliminating undesirable interests by the creation of facilities for wholesome ones. New interests may be developed

by quietly introducing new features into the environment. A great deal of versatility is obviously needed by the teacher who would meet differences existing among individuals in ability, in achievement, and in all other characteristics important to effective learning. The joy of seeing the dull relieved of frustration and the bright child challenged is a satisfying reward for the extra effort made by the teacher.

As the children of the elementary school enter the seventh and eighth school-years, it is appropriate that more attention should be given to the part science has played in shaping our civilization. Science as an element in our cultural heritage is to be considered.

The cultural aims of the teaching of science are well known. We wish to develop in children scientific attitudes—curiosity to seek answers to questions through firsthand observation and experimentation, open-mindedness which can be fostered through free discussion, and suspended judgment which waits for all evidence and checks and re-checks tentative hypotheses. An understanding of the fact that the use of scientific methods has worked revolutionary changes in men's ways of living and thinking will be brought about by enlarging upon the child's ever-present interest in the world about him and in its influence upon him. A sense of security will develop from a better understanding of the environment. A child should be acquainted with the materials and information of science which he uses every day and should be helped to understand that men have used these same data to make improvements in ways of living. The child supplied with the working knowledge of generalizations that underlie the world of science and which he can use in communication with others does not fear signs or portents, but looks for causes and effects and understands them. The subject matter of science should constitute a considerable part of the total planned program for school-years seven and eight. It may contribute greatly to that program. However, it should not emphasize subject matter as an end in itself, for the only justification for the study of science is the understanding of its facts and basic principles which can improve social life. Emphasis must be placed upon the influence of any particular bit of subject matter

in science on the children themselves, upon other people, and upon large communities of people. "How is it used?" "Is it harmful or useful?" "Is it safe?" "Should it be conserved?" and "How does it fit into an improved social life?" are questions that occur either by actual statement or by implication. The teacher should be on the lookout for every possibility of social interpretation.

No single approach to the planned program of science in the elementary school is sufficient to insure the accomplishment of the purposes that have been set forth. Every approach that is possible should be fully utilized. It is doubtless more fruitful to use certain approaches at certain times. In the preceding discussion of what we know about 12-, 13-, and 14-year-olds, it was pointed out as desirable to begin with the known interests and abilities of the children and from there lead them into new and ever-challenging interests.

A unit on hobbies in science provides an ample opportunity to begin science instruction with the present interests of young people. The following hobbies give considerable opportunity for science instruction:

1. Taking pictures with camera
2. Developing pictures
3. Making slides
4. Ornithology, or studying birds
5. Taxidermy
6. Banding birds
7. Keeping tropical fish
8. Making and flying kites
9. Modeling, firing, and glazing clay figures.

There are, of course, numerous other hobbies that have not been mentioned which may be used for science instruction.

In a hobby that leads into observation and study of living things, you will be reminded constantly of the truth of general principles of science, such as: All living things require food and water, living things produce others of their own kind, living things grow and change, some living things care for their young, animals do not produce their own food, there are many kinds of

living things, animals and plants are living things, some living things lay eggs from which young are hatched, changes in weather and season affect all living things, some living things live in communities, some living things are harmful to man, man uses many living things for his own purposes, some living things are born alive from their mothers, if living things are not adapted to live in their environment they do not survive. These general statements are, of course, related to the specific things with which you deal in pursuing your hobby. The hobby of photography would lead to the study of many of the generalizations of the physical sciences. It is interesting to note that hobbies carry one into all the various areas of specialized science instruction.

At times, it is desirable to take a specific topic, such as the air around us, and in rather systematic study find out all that we can about that topic. Some of the ideas to be explored are: Living things need air; where is air found on, in, and near the earth; can air be made to move; does air have weight; does air have pressure; what is the composition of air. One should not conclude that a topical study of the air around us confines one to the learning activities of reading books, magazines, newspapers, pamphlets, and school papers. A wealth of activities may be used in topical study which give the children an opportunity to apply the scientific method in solution of the problems confronting them. They may engage in activities such as the following: writing lists of objects; making charts of many kinds, notebooks of science, written reports, records of experiments, oral reports, interesting collections; setting up aquaria, terraria, and experiments; drawing scenes, diagrams, and other pictorial illustrations; taking trips for purposes of making observations; interviewing authorities; taking part in discussion periods and school programs; setting up exhibits and arranging bulletin boards; making surveys; performing experiments; participating in the making of plans.

Other topics which may be profitably studied in school-years seven and eight are: water and light; light and heat from the sun; gardening without soil; differences in growth; refrigeration and air conditioning; making new materials; electricity and electric signs; summer camping and science; in the science

laboratory; vocations and science; water and air at work; inventions old and new; television, radar, and jet engines; matter, energy, and the atom; agents of destruction and measures of conservation; the behavior of plants and animals; brain and mind; and a study of the universe.

The grade placement of these science topics must be regarded as very flexible. Teachers should feel free to alter this placement when they have good reason for doing so and have thought through the problems involved. Since specialized courses in science are not advisable in the elementary school, the content material in these topics may be drawn from any branch or organized field of science which can contribute to the objectives stated above. Most of the work is based on the following areas: methods of science, animals, plants, growth and change, air and water, weather, earth and sky, chemicals, tools and machines, human beings, safety, survival, conservation, magnetism and electricity, light and sound, work and energy. Facts and generalizations within the range of children's interests should be woven into activities and experiences which children should meet normally. Wherever the fact is an aid in understanding something the child wants to know, it finds its place at once in one or more of the topics. This seems the more preferable procedure because of the nature of learning and the complexity of the whole field of science. It fits better into the concept of teaching science to help the child understand his environment and to help him realize how science is used by men to improve their ways of life.

Questions that children have asked while studying the above topics give more specific information about the science content in the seventh and eighth school-years. The following questions do not constitute an exhaustive list; rather, they are a comprehensive sampling of those that may be asked.

How do light rays travel?

If light rays go from one substance to another of different density, do they keep in a straight line?

Is heated air of less density than cooler air?

What chemical changes take place in developing pictures?

What instruments use lenses for seeing objects clearly?

What are contour feathers?

Why do bluebirds come to houses with entrance holes $1\frac{1}{2}$ inches in diameter?

What is taxidermy?

Why do some birds migrate?

Why do birds sing?

Is there any reason for birds being colored as they are?

How do thermostats work?

Why does one who flies a kite run against the wind to get the kite into the air?

Does moving or still air have the greater push or pressure?

Why should air spaces not be left in clay before it is fired?

Does evaporation take place faster if more surface of the liquid is exposed?

Does soil heat faster than water?

Does soil retain its heat longer than water?

Do the roots of most plants need darkness for best growth?

Do plant roots produce acid?

Can plants be grown without soil?

Is there a possibility that nitrogen from the air will ever be all used up?

Does physical environment cause changes in growth?

What are vitamins?

How does the common cold affect growth?

Does heating a substance result in raising its temperature?

At what temperature does water freeze?

If the water were salt water, would your answer be different from what it would be if the water were fresh water?

Is air a good conductor of heat?

Could ice be made artificially in any place where it was not formed naturally?

Does ice get colder as it melts?

Does the drained water from melting ice remain at the same temperature?

Do all liquids have the same boiling point?

Does light passing through glass of different colors produce different colors of light?

Does the density of liquids depend upon the materials of which they are made and on their temperature?

What is the fulcrum of a lever?

What is latitude?

What is longitude?

What is a zone?

How would you explain the fact that during the daytime, breezes flow from the water to land?

In what direction would breezes flow at night at a seaside resort?

What is a cold front?

What is a warm front?

What is precipitation?

Do living things contain water?

What is an amoeba?

How do heat and light from the sun reach the earth?

How do plants manufacture food?

Does too much heat destroy plants?

What is photosynthesis?

What is chlorophyll?

Is yeast a plant or animal?

What is hydroponics?

What is a hypothesis?

Why are laboratories in general science very much alike?

Are there any special qualifications that a hostess on a trans-Atlantic airliner should have?

Does a parachute descend straight downward from its starting place?

How can the pull of gravity be directed into useful work?

Is water usually necessary for chemical action to take place?

How can pure water be obtained by distillation?

How does a caisson work?

What is jet propulsion?

Does ice occupy less space than water from which it is made?

How can heat energy be turned into electrical energy?

How can heat energy be turned into muscular energy?

How can sound energy be turned into light energy?

Although the laboratory comes into greater use with children of this age, one should keep in mind that many exercises that are dignified with the name of experiment are so carefully dictated

in a manual or workbook that the worker already knows the results before he does the experiment and beware of using them in the name of developing scientific attitudes. Experiments performed to find answers to real questions by the experimenter should be encouraged.

Common natural phenomena of everyday life provide the best illustrations for science instruction. Demonstration by the teacher or a committee of pupils or individual pupils may also be effective but should never replace individual experimentation.

Science Words

In the planned course in science there should be continuous growth from year to year in the vocabulary that scientists employ. Vocabularies grow out of experiences; and from the course that has been planned in this chapter, these words among others are important and indicate growth in the vocabulary of science. Science words begin to have meaning only when they are used in connection with experiences, experiments, and activities that are both interesting and real to the participants. The only real test of understanding the meaning of science words is the ability of the child to use the word correctly in science situations. In as many ways as are possible—discussions, experiments and observations, questions and answers—pupils should have opportunity to make use of these words. Parrot-like repetition of the meaning of the science word is not an end. Correct use of the word in communications is what is to be desired.

First Year

air	day	magnet	rock
animal	earth	moon	rough
autumn	earthworm	morning	sand
baby	experiment	mountain	seashore
blow	feather	night	seed
boil	garden	noon	shadow
clothes	ground	pinwheel	snow
cloud	grow	plant	soil
cocoon	home	question	spring
collection	light	rain	star

summer
sunshine
tame
things
water
weather
wheel
wild
wind
winter
work
young

Second Year

ants
aquarium
balance
bubble
burning
caterpillar
cell, dry
changes
color
direction
electric
electricity
engine
evaporate
flower
fruit
grass
height
ice
insect
leaves
lever
machine
magnifying glass
mechanical toy
moth
motor
observation
prism
pulley
rainbow
ray of light
roots
scales
seasons
siphon
stalk
steam
storm
switch
temperature
thermometer
trips
ventilation
weed
weight
year

Third Year

apparatus
backbone
belief
blood
body
brake
compass
contract
copper
difference
division
expand
fern
fog
friction
hard
invention
liquid
mammal
microscope
minute
pressure cooker
proof
raw
reflection
refrigerator
reproduce
reptile
spore
superstition
telescope
television
tuber
vapor

Fourth Year

air pressure
antenna
artificial
astronomer
bacteria
balanced diet
candle power
carbon dioxide
chemical
climate
compressed
constellation
disease germ
electric current
electric fuse
erosion
fulcrum
geologist
gravity
humus
light meter
mold
natural
nitrogen
pasteurized
planet

pollen
revolve
rotate
short circuit
substance
wind gauge

Fifth Year

amphibian
atom
cell
cellulose
chlorophyll
compost
compound
conductor
dissolve
element
embryo
extinct
foot pound
fossil
igneous
lodestone
magnetism
metamorphic
molecule
nucleus
organism
petal
pistil
protoplasm
protozoa
radiation
sedimentary
solution
species
stamen
static electricity
sterilize
trilobite
vibration

Sixth Year

adaptation
adult
altitude
annual
artesian well
axis
biennial
communication
conservation
dependence
diaphragm
displace
eclipse
energy
equator
frigid
fungus
geyser
gravitation
hemisphere
hibernate
hybrid
inoculation
insulation
larva
latitude
microbe
migrate
motion
mutant
orbit
organ
perennial
petrified
pupa
sport
stalactite
stalagmite
structure
torrid
turbine
universe
variety
zone

Seventh Year

absorb
air pressure
altitude
aneroid
atmosphere
barometer
chemical
chemical compound
chemical element
chlorophyll
concave
condensation
condenser
conduction
contour feathers
convection
convex
cortisone
density
diffuse
environment
estivation
evaporation
focus
gland
habitat
hormone
infrared ray
instinct
latent heat of fusion
latent heat of vaporization

long-chain molecule
magnify
migrate
molecule
ornithology
pancreas
parasite
photosynthesis
pull of gravity
radiant energy
radiation
refracted
refrigerant
relative humidity
research
retina
scurvy
sensitive
stratosphere
substance
sunshine vitamin
survive
synthetic substance
taxidermy
temperature
tropopause
troposphere
ultraviolet ray
vitamin

Eighth Year

anode
antenna
atom
auditory nerve
axon
bed rock
behavior
caisson
cathode
cell body
centrifugal
centripetal
cerebellum
cerebrum
comet
communicable
constellation
contagious
cyclone
cyclotron
dendrite
deuteron
disintegrate
distillation
electric eye
electrode
electron
element
energy
environment
Fahrenheit
fault plane
fission
galaxy
habit
hurricane
iconoscope
infectious
instinct
ion
ionosphere
isotope
jet
kinetic
kinescope
latent
light year
magnitude
matter
medulla oblongata
meteor
microwaves
neutron
nucleus
olfactory nerve
optic nerve
orbit
parallax
planet
positron
potential
pressure
proton
psychology
radioactive
reflecting
reflex action
refracting
response
satellite
seismograph
sensation
spectroscope
spinal cord
stimulus
telescope
tornado
tropism
vacuum tube
vertebrate
video signal
visual

Units of Subject Matter in Science

Beginning with the fourth year of science, in particular, there are many subject-matter areas in science that can be developed as units in science. The unit of science differs from the unit of

work in being confined for the most part to subject matter. The unit of science is more alive than mere mastery of the subject matter in a book of science.

In planning a science unit many different types of stimulation should be in the teacher's plans. Some of these may never be used if the interest of the group is great enough to start research after one or two methods have been tried. Some children respond to films, some to field trips and some to experiments; hence there is a need for different types of stimulaton.

After deciding upon concepts and techniques used for stimulation, the teacher should plan procedures. Some children may want to work individually, some in groups and in almost every grade a few will have to be led on step by step. The teacher should list questions which might be asked and try to lead the children to ask them, in case they do not spontaneously ask enough of their own. Books, films, and filmstrips should be ready for use. Trips that would shed light on the subject and people in the community who are experts or particularly well informed on the subject should also be included in the plans. Ways of illustrating facts learned should be considered: friezes, paintings, movies, clay models, construction, experiments, and radio programs.

Another step in planning should be ways of helping pupils see how the principles or concepts studied are utilized for man's pleasure or comfort.

From time to time as the unit of subject matter in science develops, when the teacher and pupils are planning together, many of the teacher's original ideas will be discarded for better ones offered by the members of the group. From day to day the pupils should take more and more initiative.

The following two descriptions of how science units based on animals and on sound were carried out in the fourth and the sixth years of instruction in science will show a procedure that could be used whenever, in the planned program, areas of science which are unified subject matter are met. Although many activities appear in the descriptions and in the actual carrying out of the units, it will be observed that everything tends toward mastery of particular subject matter in science.

A teacher made a careful study of the interests of a group of pupils in the fourth year of science, encouraging pupils to discuss previous units they had worked out, other activities they had enjoyed in and out of school, the types of books and periodicals they read, the movies and radio programs that were popular. Frequent references to pets, farm and circus animals, and trips to the zoo convinced the teacher that with very little stimulation the group could be led into a science unit based on animal life.

Some of the group had made a study of pets, and a few boys and girls had been in a class that had developed a unit on farm life. Considering these past experiences and the fact that their interests should be extended to other parts of the world, the teacher decided to plan a unit around these two concepts: There are many different kinds of animals in the world, and Animals have different ways of protection.

A science corner with a table, shelves and a bulletin board was made ready for articles brought to the class. Seeds, leaves, rocks, cocoons, and many other specimens were brought in and displayed.

One day a child said he wanted to bring his pet rabbit to school. Two of the boys decided to make a cage for visiting animals. The rabbit, a white rat and a turtle were brought at different times. During the discussion periods the group told all they knew about these small animals and listed questions they would like to have answered as they read their science books. The teacher led the discussion into the ways animals protect themselves. Pupils enumerated the ways they knew: shells, swift feet, protective coloring, sharp claws and horns. They decided to make a chart showing as many animals as possible under each method of protection. As they studied, they learned other means and they became more and more interested in the lives of the animals. From day to day in their discussions such topics as structure of body, reproduction, habitats, foods and ways of locomotion were introduced.

Books on animals from the school library and the public library soon filled the shelves in the science corner. Children

brought pictures and news items about animals to put on the bulletin board. Many little animals visited the classroom: a cat, a snake, a hamster, and numerous insects.

Organization was necessary to keep the interests from going into so many channels that the children would fail to get a real understanding of any one concept. After many periods of planning, the children decided to work in four groups. The four topics they selected for study were:

1. Animals of hot countries
2. Animals of cold countries
3. Desert animals
4. Water animals.

Each child was asked to choose his or her committee.

They agreed that every group would get as much information as it could, but they would also attempt to include the following facts in their reports:

1. Where the animals live (locate places on map)
2. Their appearance (body structure, fur or hide)
3. Their homes
4. Their food and how they get it
5. How they are protected
6. Their uses to man.

This information was to be acquired from books, from filmstrips, films, consultations with specialists in high school and college and from trips to the zoo, the museum, and the park.

It was to be reported to the class in any way the group chose, but everyone agreed it should be told in children's own words and some type of illustration would be needed.

At the end of eight weeks the reports were given. The members of one group had made a frieze showing typical animals in their category. When it was presented to the class, each committee member made a report on one specific animal represented on the frieze.

The second group had made dioramas for animals in its area of study. The background was painted and pasted in the back of the box. The animals were made of clay and painted in natural

colors. Thumb-tacked under each box was an original story of the animal written by the child responsible for making that particular diorama.

Group three secured an excellent film from the visual aids department. After it was shown, each member of the committee gave a short talk giving additional facts he had learned from other sources.

The members of the fourth group made individual booklets with their own stories and pictures of each animal. This group also told about the aquarium the members had prepared and cared for.

At the completion of the unit of study, the class made a list of the following facts and generalizations they had learned:

1. Some animals live in colonies.
2. Some live in herds.
3. Some are born alive.
4. A mammal has a backbone, reproduces its young alive, and feeds them milk from its body.
5. Some animals are born from eggs.
6. Some eat other animals; some eat plants.
7. Some are amphibious and can live in water or on land.
8. Animals have different ways of preparing for the winter: hibernation, migration, changing color, fur getting thicker.
9. Animals are protected by teeth, claws, horns, swift feet, coloration, needles, and scent.
10. Some animals are warm-blooded; some are cold-blooded.
11. Some live in many parts of the world; some in only one or two areas.
12. They are useful to men in many ways: clothes, food, labor, pleasure, and medicine.

Sound—A Unit of Subject Matter for the Sixth Year

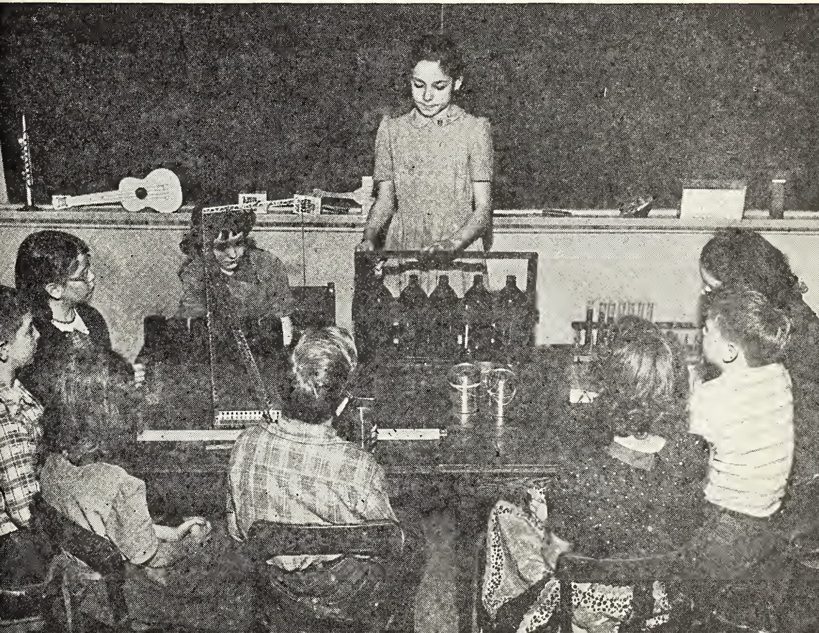
A trip to a newly-erected telephone building at the invitation of the company was the incentive for a study of sound in a sixth-year class. The discussions that took place in the classroom and the numerous questions that were asked after their visit made the teacher realize that an organized unit of subject matter related to sound would be the best way to satisfy their curiosity.

The teacher's plans listed the following aims:

1. Major concept to be developed:
   Man has learned how to use natural resources to improve his manner of living and to get more pleasure out of life.
2. Other truths and concepts to be developed:
   a. All sound is made by vibration.
   b. Sound travels.
   c. Sound travels more easily through some substances than through others.
   d. Sound travels in all directions from its source.
   e. Pitch depends upon speed of vibrations.
   f. Highness and lowness of sound depends upon the force of the vibrations.
   g. All musical instruments produce sounds through vibrations.
   h. Vibrations may be magnified by the megaphone.
   i. Many unpleasant noises may be eliminated.

A study of sound may be a unit of subject matter in science as well as part of a broader experience unit.

Louisville Public Schools, Louisville, Ky.



j. Sound waves bounce back to their source as an echo.
k. The presence of echoes in a room produces poor acoustics.
l. In churches and public buildings today experts plan the rooms and halls so as to have good acoustics.
m. Vibrations of the vocal cords produce our voices.
n. Colds and hoarseness affect the vocal cords.
o. We hear sounds because the sound waves travel to the ear and cause the eardrum and the bones in the inner-ear to vibrate.
p. It is important that we care for our ears.

3. Other aims of the teacher:
   a. To develop an appreciation of our natural resources as they have been used for man's adaptation to his environment.
   b. To help children realize that there are interesting things about us.
   c. To develop an open-mindedness through observations, discussions, and experiments.
   d. To demand sufficient amount of proof before the acceptance of new theories.
   e. To develop the ability to make correct and interesting reports.
   f. To develop leadership in group study.
   g. To develop cooperation through group activities.
   h. To acquire an adequate speaking and reading vocabulary.
   i. To develop creative expression through art, writing and dramatics.

Children's Aims: To find out how sounds are made and carried.

In the daily program the teacher decided to give one hour a day to the work on the unit on sound. In that time plans were to be made so carefully that every child would know what he would do and would have the necessary materials. Some would work in groups and some would do individual work. The last part of the period would be used for reporting on what had been done and in making further plans.

The teacher realized that the best evaluation of the unit would be improved work and study habits and more intelligent use of reference material. However, the teacher and pupils planned to give a play at the end of the unit to summarize their learnings.

Following the discussions of their visit to the telephone plant, the children decided to make a collection of articles that produce sound. All kinds of objects were brought—musical instruments, whistles, a comb, rubber bands, balloons, tin cans, a stick, and many others. One child did not bring anything. When asked her reason, she said, "I brought myself. Mother says that I'm the noisiest thing around our house."

The children sat still and listened to the sounds in the room—the clock ticking, birds singing, cars and trains in the distance, and someone walking in the hall.

They made a list of questions they hoped to answer. This list was placed on a chart with space left at the bottom for new questions to be added as the unit of study developed. They also listed the ways they would acquire the needed information:

1. We will use our science books.
2. We will use every reference book we can find.
3. We will visit the airport and the music store.
4. We will ask Mr. B to help us. (Mr. B was a teacher who had majored in science.)
5. We will see movies and filmstrips.
6. We will ask Mr. C how acoustics in a room can be improved.
7. We will work in committees and make oral reports to the other members of the class.
8. We will get the art teacher to help us with the illustrations we will use in making our reports.
9. We will try many experiments.
10. We will write a description of each experiment, what we did, what happened, and what we learned.

After several weeks they added another plan. It was to give a play about Alexander Graham Bell and the telephone.

As each simple experiment was performed, the children wrote a description of how it had been done and the results.

The following accounts were taken from one child's notebook.

1. We wanted to know what sound is. We held a strong knife tightly at the edge of the table. We pressed down on the handle with one hand; with the other hand we pressed on the blade. We let go suddenly; the blade moved up and down. We learned that the movements are called vibrations.

2. We held our hands to our throats. We felt the vibrations.

3. We learned that certain sounds are made by using our lips, tongue, teeth, and throat.

4. We used two coffee cans the same size. We punched a hole in the bottom of each one. We connected the two with fifty feet of string. Mary went into one room and Ted into another. Both of them were using the cans as telephone receivers. They carried on a conversation and could hear each other. We learned that sound travels when certain things carry it. These things are called conductors.

5. We took a piece of steel that was used for automobile springs. We tapped it and noticed the clear ringing vibrations it sent out. Then we heated it and tapped it again. There was a dull thud. We learned that heat changed the vibrating quality of steel.

6. We recorded our voices at the beginning of the unit. The record was played, and each one of us listened to our own voices and the voices of the other children. Then we tried to see if we could not learn to speak more distinctly, and at the last of our unit we recorded them again to see if we had improved. Some of us had and some had not.

Health books were used to learn more about the parts of their bodies that were used in talking and hearing. The children acquired a realization of the importance of caring for the ears.

At the close of the unit on sound the play was presented, after which the audience was invited into the classroom to see the friezes of sound waves, musical instruments and the radio, the charts and the individual booklets of the pupils which contained illustrated written accounts of their experiences.

Similar units of subject matter in science might appear in any year of the planned program. They may be suggested by the

items in the planned program, by incidental happenings, by seasonal changes, by special interests of one or more children or by any of many other avenues through which a program of instruction in science is approached.

The planned program in science is improved by the use of units of subject matter, by units of work and by interests aroused from incidental happenings. Everything possible should be done to prevent the planned program from becoming a mere recital of facts from outlines or textbooks.

Increase Your Understanding

1. Examine several courses of study for science and compare their suggestions for areas to be covered with those suggested in this chapter for the elementary-school years. Do you find general agreement in the suggestions? Account for what you discover.

2. Building upon what you have learned in this chapter and in the courses of study you have examined, construct a workable plan for science in one of the school years. List all the experiments you would include and the apparatus you would need.

3. Examine a textbook in science prepared for that one of the school years for which you made your plan. How nearly does the content of the textbook parallel the content of the course you planned?

Additional Readings

California State Department of Education, *Science in the Elementary School*, Sacramento, 1945. 416 pp.

Florida State Department of Education, *A Guide to Teaching Science in the Elementary School*, Tallahassee, 1947. 88 pp.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 75–78.

Nebraska State Department of Education, *Science for Nebraska Elementary School Children*, Lincoln, 1950. 204 pp.

North Carolina State Superintendent of Public Instruction, *Science for the Elementary School*, Publication No. 227, Raleigh, 1941. 115 pp.

Ohio State Department of Education, *Science Education for the Elementary Schools of Ohio*, Curriculum Bulletin No. 3, Columbus, 1946. 192 pp.

South Carolina State Department of Education, *Suggestions for the Teaching of Science in the Twelve-Year School Program*, Columbia, 1946. 115 pp.

Utah State Department of Education, *Science Supplement to a Teaching Guide for the Elementary Schools of Utah*, Salt Lake City, 1946. 93 pp.

Chapter 8

Utilizing Community Resources for Science Teaching

THE literature of education abounds with articles exhorting the teacher to take advantage of community resources. Elementary science, while rather new to the elementary-school curriculum, is no exception to the possible application of community resources. In fact, it is one of the outstanding examples of an area wherein profitable use is almost unlimited. Although there has been increased use of community resources by alert teachers, extensive use is by no means universal.

Factors Inhibiting Use of Community Resources

One can easily identify some of the factors inhibiting the use of community resources. Teachers are so accustomed to the kind of teaching and learning based on "recite"-ation from a book that they do not recognize the magnitude and variety of possibilities. More time and planning is required for this kind of a learning experience. Consequently, teachers whose daily program is a series of 20-minute periods will feel a restriction of time—perhaps unwarranted—but, nevertheless, real to them. In some communities, among lay people and school people alike, there is a tendency to look upon any activity occurring outside the classroom as a picnic, party, or sight-seeing tour. No planning, or inadequate planning, of community learning experiences has often led to their identification as a holiday festivity of the type

in which uncontrolled enthusiasm leads to destruction of property. Teachers who do not plan with their children have missed an opportunity to get across the educational significance of the activity and usually find they have suffered a loss of prestige as effective leaders. The lack of budgeted funds for educational trips sometimes serves as an excuse for a teacher's failure to recognize and to use the wealth of materials at her "finger tips." None of these arguments against using the community is insurmountable.

Reasons for Utilizing Community Resources

If teachers are to play a major role in the education of children, it is imperative that they utilize the community resources directly and continuously. This utilization makes it possible for the child to learn in a setting that is real and understandable to him. The complexity of our culture makes it necessary for the school to clarify for pupils the processes of living which no longer exist in simple form in their homes. One of the most important objectives of education is to help the child to know and understand his environment, its impact on him, and the necessity of modifying it or adjusting to it. Even the vicarious experiences of the typical classroom become progressively richer and understandable as a background of real, firsthand experiences increases.

This emphasis on real, direct, firsthand experiences should not be interpreted as a condemnation of vicarious classroom experiences. The learnings which occur in the community and the classroom when properly planned supplement and strengthen each other. It must be admitted, however, that there are units in the curriculum for which the use of community materials is difficult to arrange and not conducive to understanding. Poorly planned excursions may also be a waste of valuable time for the teacher and the pupils.

In summary, the teacher should make well-planned use of community resources, for:

1. There is a wealth of material readily accessible.
2. Rich, direct experiences supply verification and enrichment for vicarious experiences.

3. The use of community resources provides a variety of approaches to learning which avoids mystifying the dull and boring the bright with an exclusive diet of "canned" verbal learning.

4. Children learn most readily from firsthand experiences which give them sensory impressions of feeling, smelling, seeing, and hearing.

5. Abstractions may be made concrete and real.

6. Science is thus identified as being everywhere in our daily living, instead of being a mystic laboratory abstraction.

7. Information purely local in nature or for any other reasons not accessible in school sources may be obtained in the community.

8. Powers of problem solving and keen observation in the out-of-school environment may be developed.

9. The use of scientific discovery in improving community living is copiously illustrated.

10. The use of results from contacts which are made develop good school and community relations.

Extent of Science Possibilities in Community Resources

In an earlier chapter, it was stated that one of the most common reasons given by teachers for not teaching science in the elementary schools is the lack of adequate equipment and teaching facilities. Because of this felt need for materials, teachers may begin a survey of the extent of community resources by seeing what materials and equipment are available from local sources. It is obvious that some of these items may be borrowed, some will have to be purchased, and some will be given to the schools to become a part of the science equipment of the classroom. They are obtainable from the home, the variety store, the drug store or the hardware store.

Suggested List of Useful Material That Could Be Collected from the Environment

Living things: Fish, snails, water plants, birds, growing plants, turtle, frog, salamander, snake, larvae of different kinds, cocoons and chrysalises, seeds, ants, and other insects.

Hardware: Flat tin pan, steel wool, flashlight, tin funnel, teakettle, steel knitting needles, paring knife, tin cups, pie tin, hammer, saw, pliers, screw driver, nails, tacks, screws, large bolts, triangular file, tin shears, scissors, small electric plate, glue and paste, paints, varnishes.

Glassware: Fruit jars of different sizes, pint and quart milk bottles, olive bottles with long straight sides, glass tumblers, lamp chimneys, small perfume bottles, fish bowls, windowpane glass, and various types of heat resistant glassware.

Rubber: Rubber syringe, hose, balloons, elastic bands, atomizer and hose, tennis balls and other types of rubber balls.

Chemicals: Soda, starch, sugar, lime, red ink, vinegar, table salt, paraffin, ammonia, iodine, dyes, turpentine, alcohol, moth balls.

Miscellaneous: Worn-out dry cells; tin cans; oil cans; cups, saucers, dinner plates; teaspoons; tablespoons; sandpaper; string; safety matches; cellophane; blotters; candles; thread; bees wax; chalk boxes; cigar boxes; hard rubber comb; pieces of silk, wool, fur; flower pots; ice cream containers; marbles; chips; scissors; scraps of different kinds of metal; worn-out electrical appliances; soil samples of sand, clay, loam, humus; medicine dropper; hot plate; needles; tack puller; mirrors; mechanical toys; colored chalk; tongs; egg beaters; pet cages; yardstick; nut cracker; wedges; thermometer; musical instruments of various kinds; gum labels.

The foregoing list is a composite of many lists from different sources, supplemented by suggestions from elementary-school teachers. The accumulation of materials from the community to be used for science teaching is one of the obvious and simple uses of community resources.

Alert teachers make uses of community resources which are less obvious. At a fourth-grade sharing period Ted showed the group a rock with the imprint of a fern clearly etched on its surface. He asked the members of the class if they knew how it was made. A few children knew it was a fossil, but none understood how it was formed. As a result of their research, they became so interested that every child longed for a fossil of his own. Ted told them he had found it under a bridge over the Kentucky

Wheelock College, Boston

In assessing community resources for field trips, a place where loose specimens are available is to be preferred.

River and there were many others there, enough for every child to have one for himself.

The bridge was only a few miles from town. After the teacher had made a visit to the spot to assure herself that a field trip there would be of real value, they made plans to go fossil hunting. Not only were they able to acquire specimens of their own, but they saw an excellent example of a fault in the rocks above the road which stimulated further research.

As no one in the school system had previously utilized this source of science learning, the teacher suggested that the children write to pupils in other schools about their discovery. This they did and many classes have made excursions to the bridge.

The children were so elated over the idea of a nine-year-old discovering a place of interest to other schools that they went on

explorations of their own to locate other sources for science learning. One that was discovered in this way was a forgotten clay pit where pottery had once been made.

It has been contended that each of us has a zoo in our own yard. Naturalists suggest that very profitable experiences can be derived from the study of the summer colony of insect guests which may be found very close to our homes. In the bushes and grass-root jungles of the yard are many creatures which may be used for science instruction—namely, the bumble bee, grasshopper, swallow-tail butterfly, praying mantis, daddy longlegs, dragonfly, lady-bug beetle, Monarch butterfly, honeybees, cricket, aphids, ants, moths. These backyard visitors can be attracted by planting Buddleia or butterfly bushes and other shrubs. Schoolyards probably abound in these resources for science teaching.

An interesting study of the science resources immediately surrounding the school building has been conducted on the University of North Carolina campus at Chapel Hill, North Carolina. An instructor in the teaching of science in elementary schools whose classroom was in the education building asked the students to make a survey of the building and an area of perhaps one hundred feet in each direction outside the building for leads into the use of the community for teaching science. There were two unusual features of the environment. The University maintained a sort of plant nursery just across a lane beside the building, and there was a small weather station near the building. Instruments for the weather station had been set up outside, probably for use in the Physics Department in the University which is near the education building but outside the limit set for the survey. The education building and its environs were only in those two respects different from an ordinary school building in any community.

The following report,[1] with its final comment and bibliography, was submitted by Mrs. Ruth Anthony, one of the students. It is evident that the student used references in making identifications. Mrs. Anthony's running comments show how much the environment meant to her as a prospective guide to students in

[1] Used by permission

using the resources of the community in understanding science. The report is given here just as it was turned in to the instructor. This report is similar to that given in Chapter 3, but the environment is different. It is an environment surrounding a school building and, for that reason, suggests how teachers may begin to use the immediate environment. No means of transportation except feet and legs would be required. Regular class time would suffice for making use of this environment.

Trees:

Shade—green ash, white ash, red cedar, red maple-seedling, sugar maple, Norway maple—hard maple, black oak, white oak, pin oak, red oak, willow oak, water oak, Linden, red gum, American elm, winged elm, Chinese elm, black locust, Lombardy poplar, Boleana poplar, Catalpa—seeds make good camp-fire tender.

Fruit—double flowering peach, wild plum—with small fruit, red mulberry, white mulberry, peach, hawthorne—with fruit, fig—abundant fruit is forming.

Cultivated ornamental—sweet bay, cutleaf maple, Royal Paulownia, Chinaberry, Japanese varnish tree, mimosa—leaves sleep at night, dogwood—with seeds, magnolia—in bloom, ornamental plum, redbud, smoke tree, American holly, English holly—darker green than American; shade—box elder—maple family sometimes called "three-leaved maple," Carolina poplar, silver maple.

Evergreen—Cedar of Lebanon, spruce, Chinese fir, longleaf pine, short-leafed pine, hemlocks—with little pendant cones, Arbor Vitae—the rarest tree growing wild in North Carolina (Coker), Chamaecyparis—ornamental arbor vitae, Podocarpa—lovely Japanese conifer, Japanese yew, cypress.

Nut—pecan, hickory, black walnut-seedling. Innumerable small seedlings in nursery garden. Note rich humus formed from decaying leaves, stumps, twigs, grass. This nurtures plant life very well.

Shrubs:

Cultivated—Chinese privet; Yaupon Holly—the female tree (with berries; Indians used the leaves for tea; sometimes people use them for tea today); bush honeysuckle—several varieties, Viburnum-snowball, barberry, yucca, hydrangea, Hibiscus Syriacus-althea, cotoneaster—several varieties, abelia, vitex—purple

and pink blossoming, Euonymus, croton—yellow and white speckled leaves, nandina Philadelphus—a mock orange, crepe myrtle, spirea vanhouttei, spirea thunbergia, spirea anthony waterer, Cherokee rose—state flower of Georgia (has a white bloom), hybrid tea roses, azalea, forsythia, naked jasmine—blooms in January before leaves appear, lilac, boxwood; japonica—note leaf whorl (several varieties of this shrub); ligustrum japonica—not Lucidum as first shipped from Europe, broad, dark green, waxy leaf; ligustrum quihoui—long willowy blossom spikes, attracts bees; beautyberry—French mulberry, callicarpa (dainty composite purple blossom, fruit will also be purple); common juniper, pfitzer's juniper.

Wild—jetbead—has four shiny seeds, huckleberry, bull bay—persea, magnolia family, dwarf buckeye; trifoliate orange—strong rootstock, used in grafting hybrid oranges; in the large Florida groves, thorny, has tiny, fuzzy green oranges (Britton). Many of these shrubs had green seedpods forming. Children would enjoy planting when ripe and watching to see which grow readily, which do not. The nursery contains many seedlings.

Flowers:

Wild—yellow sundrops, violets, asters—several varieties; oxeye daisy—once the North Carolina state flower (dogwood now is).

Cultivated—hemerocallis—day lilies; liliacae liriope—planted in shady, moist places in lieu of grass (blue flowers and berries); larkspur, buddleia, iris—numerous varieties, lily of the valley. Nail kegs are placed throughout the nursery garden and contain flowers. These are not well tended this year.

Vines:

Wild—blackberry; dewberry—heavy, red vine (ripening berries); Virginia creeper—a menace to field crops in places; Kentucky trumpet vine; poison ivy; Japanese honeysuckle—pest; Indian strawberry—yellow bloom (insipid red berry); bittersweet—seeds forming; grape.

Cultivated—vinca-periwinkle, euonymus, hybrid climbing rose, wistaria, Boston ivy—foundation planting; common Boston ivy—grows on tree trunks by clinging for support (budding); English ivy; woodbine; Eusyssus—pepper vine (has buds and lacy, pinnate leaf); Carolina jasmine—yellow jasmine (not a true jasmine, but a drug plant).

Fungi:

Several varieties of mushrooms. Children must be cautioned against touching these. Some are poisonous. See Comstock, section on mushrooms.

Simple plant life:

Fern—simple, wild rock ferns; moss on north side of tree trunks, in moist or shaded places on lawn and near buildings, under bushes; lichens—observe pleurococcus under microscope.

Grasses:

Foxtail (cheat—so-called because it grows in oats), bluegrass, Kentucky bluegrass, sedge grass, Bermuda grass, crab grass, Johnson grass, clover—red and white, orchard grass. Numerous other varieties of grass. One is like a bullrush in seed stalk. One has broad, yellow-green blades.

Weeds:

Plantain—several varieties, one is called "buckthorn"; milkweed, compass plant—wild lettuce, lamb's quarters; Virginia spiderwort—like a wandering jew, dainty blue blossoms; Japanese honeysuckle, rabbit's foot—stone clover, cutweed—silvery rosette of leaves; dandelion—in bloom, false nettle—is furry; three-leaved pea—is fuzzy, pulse family; horse nettle—spiny (has dainty pale lavendar blooms); mare's tail, peppergrass—tongue grass, shepherd's purse, yellow wood sorrel—oxalis, rattlebox—pulse family; lyre-leaved sage—lovely, purple-veined leaves (mint family, plant looks vaguely like African violet); ragweed—two varieties, morning glory vines, wild asters, pokeberry, vermifuge—spearmint scented, Indian (fool's) parsley, Indian strawberry—spreads by runners, mullein.

Insects:

Stag beetle—a wood beetle, useful, see the Insect Guide (Swain); large wood ants—note pile of sawdust they make; several varieties of small ants—in anthills, on trees, in rotting stumps; termite—in rotting plank; flies—common housefly, bluebottle, horsefly; butterflies, moth—also a sphinx moth, grasshopper, beetles, bumblebees pollinating Cherokee roses and abelia; spittlebug in weed stems—galls on leaves, stems, and trunks; honeybees pollinating varnish tree and Cherokee roses; fireflies, mosquitoes, cricket, ladybugs, mud-daubers and nests on building—wasps; hornets and nest—paper, yellowjacket wasps; tent caterpillars on pecan tree—bagworms on a tree in

peach family; a small insect that looked much like a boll weevil; aphids—plant lice, ant cows, ants were "milking" these; leaf hopper, cicada; reproduction: a pair of June beetles; gnat, blue-winged wasps.

Rocks and soil:

Limestone—a sedimentary rock; slate—blackboards; chalk—tiny shells, white cliffs of Dover; marble cornerstone on building; granite—in rock walls; sandstone, crushed stone and sand in walks; well-weathered boulders of limestone near driveway—discuss causes of roundness or jagged appearance in rocks; small quartz and feldspar rocks in sidewalk covering; man-made rock products: mortar between bricks, bricks themselves, cement on curbs of street, concrete blocks, red, yellow, blacktop streets, tar, sand, gravel, plaster, marble-chip floors in hall; soil: sand, loam (sand, clay, silt, humus), clay, silt (like sand, but smaller particles).

Miscellaneous:

Cedar—apple rust spores on an apple tree (rosacae family) in nursery. This is alternate host. Juniper or cedars are host. Tent caterpillars in red mulberry and pecan trees. Green leaves—manufacturing plant food; man cannot make his own food, but leaves can. Leaves turning autumn colors—children will investigate the reasons; insect damage, dry weather, plant injury; chlorophyll is withdrawn by the plant, to retain it. Floating spiderweb—discuss how this can happen. Erosion—slight, on slopes of lawn; small exposed depressions are filling with silt and sand; the side of the blacktop near Operating Stores has eroded badly; water and tree roots hasten the process; a tile conduit is exposed here. Cracked pavement—causes? White line on pavement for parking—discuss road safety here. Greenhouse—locked; a padlock is a most useful tool; inside the greenhouse are seen seedflats, plant beds, clay pots; tropical plants, cabbage palmetto, banana tree, citrus tree, snake plant, tiger tongue, cactus, red pepper plant, geraniums, begonias. Coal and coke in cinder path. Rotting stumps and boards—one stump showed tunnels of a wood-borer; woodpeckers help trees by eating these. Ventilation inlets on building. Ventilation glass set at angle in window to prevent drafts and still supply fresh air. Rubber shoescraper mat—note geometric design caused by construction. Copper strips between blocks of marble-chip floor covering—for expansion in summer and contraction in winter to avoid cracks. Erosion on steps caused by much walking on them. Sand in box-like cement urns for extinguishing cigarettes.

Mailbox—introduce unit on post office. Landscaping of grounds. Rare imported trees and shrubs from many lands in nursery; may arouse interest in studying the land of origin of, say Chinese fir, for social studies. The grass is kept trim—discuss reason for cutting grass and proper length to cut it. Gravity holds buildings in place; people to earth. Shadows. Cars with license plates from many states—geography concepts. Water—drinking; discuss how we get pure water. Paths and sidewalks—discuss how these are made. Oil on pavement—formed rainbow in rainstorm. Books. Telephone poles with wires; braced with supporting wire. Insulators—why use? Terracing behind building from road. Drainage canals—little V-shaped troughs, brick-lined, beside walks; larger drainage ducts covered with iron grills, carry larger quantities of water to sewer lines, hole is brick-lined to prevent erosion; long, narrow slits at sides of curbs to drain water; manhole in street; downspouts on building to an open, grill-covered drain. Bone brought by dog. Snake hole; insect holes in ground, some are grass-lined. Uprooted shrub in nursery garden—discuss cause; yellowing leaves. Water spigots in nursery. Gnarled "warts" (galls) on tree trunk caused by insect; tree's way of protecting itself. The Universe: sun, stars, moon, planets; wind and weather—air is all about us; dust, soot, smoke, breezes, wind; sunny weather, cloudy, rain; very hot and quite cool weather; rainbow; clouds: cirrus, cumulus, stratus, nimbus, nimbostratus; seasons: summer, very warm; heat more noticeable after rain. Light is necessary for seeing objects in nature—natural light; electric light; reflector on bicycles.

The Building, Outdoors and In:

Roof—tile; eave troughs and downspouts. Wood, stone, brick, metals, cement, plaster. Furnishings to make the environment functional for learning. Electric lights, circuits, fans, telephone; pencil sharpener. Machines—typewriter, adding machine, mimeograph, stapler, projector, projector screen. Fire hose, fire extinguisher. Radiators for winter warmth; windows for summer air circulation. Gooseneck water trap on sinks. Water taps; drinking fountains. Plumbing and sewage disposal. Books, magazines, pamphlets, newspapers. Wedge principle—tacks, nails, wooden doorstops. Chair gliders to reduce friction and protect floors. Stairs—adapted inclined plane. Watches; electric clock. Cracks in wall—discuss causes. Glass—window, lets light in and out; lamppost; bottles, and bits of broken brown and blue bottles; car windshields; people's glasses. Glass is made from sand or quartz, soda ash, potash, lime, lead oxide, niter, and

possibly coloring material. Linoleum floor and stair covering. Marble chip floors with copper strips for expansion and contraction. Metals—auto body, iron plate across drain, iron grills, iron lampposts, signposts, radiator in classroom, map stand, copper strips in floor of hall, stair railings, window catches and lights, screws to hold furniture together, garbage disposal cans, wastebaskets. Doors—hinges, wood, glass, screws, doorstops, door-closing mechanism, knobs, locks, nails, paint. Building materials—wood, stone, brick, plaster, concrete, glass, metal.

Electricity:

Fluorescent lamps; ordinary lights; clock; fan. Light circuits, light bulbs, switches, plugs, outlets, wires. Street light—suspended over intersection, find other types. Traffic light control box. DC for lights on car and bicycle. Telephone.

Machines:

All five types are represented. (See Craig pages 415, ff.) Scales. Lawn-mowers. Pencil sharpener. Bicycles, some with motors, some foot-powered. Motor scooters. Automobiles—old and new; streamlining. Pulleys to raise and lower windows; gravity; we raise windows to get fresh air. Window latches. Door locks. Doorstops—mechanical; wedge. Typewriters. Mimeographs. Electric fans.

Sound:

Cars passing. Bell from tower sounds across campus. Thunder. Telephones. Bird songs. Squirrel's feet patter on sanded path. Birds rustling in dead leaves in nursery. Insects droning steadily. Bees buzzing. Wind thru trees. Dogs barking. People talking; walking on crushed rock paths.

People:

Types of clothing worn—wool, cotton, nylon, silk, rayon, linen. White race, Oriental races, Negro race. Men, women, children. Shoes—leather, many types; rubber heels. Buttons—pearl, plastic, metal. Costume jewelry—gold, silver, brass, aluminum, stones of various sorts and colors. Metal zippers and snaps.

Heat:

That caused by sunlight; thermometer. Furnaces for winter warmth; radiators. Running cars radiate heat waves; sunlight reflected from parked car bodies pulsates heat waves.

Animals:

Brown rabbits. Spider and web—one web was dainty and round, one was like a mesh in a bush; falling petals from vitex made it look very pretty; spiders are arachnids, not insects, have 8 legs. Gray squirrels—also nest in oak tree. Toad in nursery. Chipmunk—this one, frightened, started climbing a tree! Earthworms—come up for air after rain; rain drives air bubbles from soil. Wormy plums—some on tree, some fallen to ground and ripened before time; harmful animal; discuss spraying. Pets—many varieties of dogs; cats; a kitten. Birds—brown thrasher; wood thrush; cardinals, mates are usually seen in same vicinity; catbird; mocking bird; robins; English and song sparrows; kingbirds, male has red dot on crown of head, mates are often seen in same vicinity; red-headed woodpeckers, a pair; pigeons, note iridescent plumage; chimney swifts, over Carolina Inn. Reproduction: male and female birds; nests where young are sheltered, in bush, in tree. Woodpecker holes in tree bark to get tree borers. See also section on insects.

Processes in Nature, Activities of Animals:

Ants milking aphids on hybrid rose bush. Thunder and lightning. Petals dropping from blooming privet. Bees, flies, wasps, gnats buzzing around pepper vine, Cherokee rose. Stars twinkling at night. Dew, prism effect in sunlight. Birds singing and flying, feeding. Squirrels hopping, leaping, climbing. They eat bread crusts and ice cream cones! Weathering of stones in stone wall; plants growing between rocks also hasten the breaking-down process. Green leaves making plant food. Leaves eaten by leaf miners, cutting insects, tent caterpillars. Seasonal changes in weather; temperature. Black paint on stumps of crepe myrtle that has been cut down; prevents "bleeding." Expansion and contraction of copper strips between floor squares, marble chip and concrete, with temperature changes. Plant seeds from trees and shrubs to see if they will grow. Some shrubs produce sterile seeds; lilac, yucca. Break off a plantain leaf. What use are the long "strings" to the plant? Prune off flowering stalks when shrubs finish blooming to add strength to plant. There was a whip graft on a mulberry tree in nursery.

The Weather Instruments:

Wind vane. Weather recording station—Anemometer, measures wind velocity; wooden box on stilts, shuttered, is locked but it contains sensitive weather-recording instruments: drum-recording barometers, barograph, thermometers; cylindrical

flue, with funnel built in, for collecting light precipitation in wooden, box-like mounting to hold it upright; drum, like miniature stock tank, containing rain water with gauge at side, silver paint prevents rusting of tank. This equipment is fenced in. Steel pipes form the cornerposts. Strong wire fence. Padlock on iron gate. Rubber water hose. What other materials are now used for making garden hose?

There are innumerable science opportunities both outdoors and within the school building to furnish an abundant and worthwhile science program all year for any age level of children. It all depends on the teacher's being alert to the obvious learnings in the environment and knowing how to build science learnings from everyday surroundings.

References: Chapman, *Flora of Southern U. S.*
Coker, *Trees of Southeastern U. S.*
Comstock, *Handbook of Nature Study*
Gray's *Manual of Botany*
Green, Charlotte H., *Trees of the South*, *Birds of the South*
Pough, Richard H., *Audubon Bird Guide*
Swain, Ralph B., *The Insect Guide*

Mrs. Anthony here tells of her training for science. She says, "My father, a veterinarian, was interested in nature. Nearly every Sunday afternoon he took my little brother and me for nature walks, quoting poetry and scripture and explaining about the trees and rocks, birds and flowers. Then we children would go to the very small public library to find additional poetry on nature or pictures of flowers, rocks and birds of which father did not know the names.

"I studied General Science and Biology in high school and Elementary Physics for Teachers and Botany at State Teachers College. These four courses are the only specialized training I have had.

"Because of my father's early guidance, from my first year of teaching in a rural school, I have always enjoyed incidental teaching of science through the feathers, leaves and stones which children always bring to school."

Mrs. Anthony is probably representative of the average teacher who will be expected to carry forward any program of teaching science in the elementary school. She had had one inestimably

valuable assistant, her father, who had given her a first acquaintance with the world about her. That kind of assistance and acquaintance is what the elementary-school teacher can give pupils.

The modern home has numerous possibilities for science teaching. One fourth-grade class which had studied science in the home for a few weeks made a list of science generalizations that had come from their study. The list is reproduced here to show the extensive nature of their consideration.

How Facts of Science Are Used to Make Better Homes

I. Facts about Heat
   A. Heat travels faster in some materials than in others.
   B. Heated air rises.
   C. Heated water rises.
   D. Heat stays longer in some metals than in others.
   E. Friction causes heat.
   F. Burning fuel makes heat.
   G. An electric current makes heat.
   H. The sun gives heat.

II. Facts about Light
   A. Light travels in straight lines.
   B. Light can be reflected.
   C. Surfaces that are lighter in color reflect more light.
   D. Burning makes light.
   E. An electric current makes light.
   F. The sun gives light.

III. Facts about Water
   A. Water has force.
   B. Human beings need water for drinking.
   C. Water helps keep things clean.
   D. Water runs from higher to lower places.
   E. Air can be compressed to force water uphill.
   F. Sometimes water flows underground.

Further illustrations of the resources for science teaching in the home may be found in the extent to which physical sciences are observed in kitchen operations. The study of energy may involve calories. The mechanical refrigerators and the gas refrigerators provide an opportunity to see in action the cooling

effect produced by the evaporation of a liquid. Teakettles provide an opportunity for the production of clouds. The vacuum bottle used on picnics illustrates heat insulation. Vacuum coffee makers make application of a number of science generalizations involving heat and air. Inertia may be illustrated by attempting to spin a fresh egg and a hard-boiled egg and noticing the result. The fresh egg will hardly spin at all because of the two different liquid masses inside. The thermostatic controls in the modern kitchen also illustrate the use of bimetallic strip for heat control. This obviously illustrates differences in the rate of expansion and contraction of different metals when exposed to heat.

The application of chemistry instruction to cooking has many obvious possibilities. We cook carrots. We scramble eggs. We toast bread. We fry bacon. We bake a cake. In these changes something happens to the substances in the food that makes it different from the substance with which we started. Chemical changes caused by application of heat are common in the kitchen. The chemistry of soap and detergents offers interesting possibilities. Other possibilities are to use kitchen materials for demonstration of tests for acids and alkalines. Lemon juice may be used as invisible ink and carbon dioxide produced from vinegar and soda may be used as a fire extinguisher. Obviously, science is not confined to any one room of the home. The living room provides the radio, television, indirect lighting, fluorescent lamp, and in other parts of the house, mirrors, air-conditioning, and other furnishing and equipment may be observed and studied as part of science teaching.

Using Simple Toys in Teaching Science

Toys in varied stages of complexity are resources in all communities, and they can be used for teaching science. They are often brought to school by children, and sometimes projects of repairing them and restoring their original attractiveness are undertaken. They make practical use of many of the principles of science. Children themselves may make toys and find out much about science in doing it.

Pinwheels are easy to make, and even small children can make and operate them. The faster the child runs, the faster the wheel

Cleveland Public Schools

Children's delight in magnets can be broadly extended.

turns. The wheel must face the direction from which air moves against it. From pinwheels an easy transition can be made to water wheels and the forces of wind and water to make wheels turn and to help make man's work easier. Propellers on toy airplanes are further extensions of the use of principles of science in building toys that turn.

Pre-school children delight to play with magnets, and children of eight or nine years and older can easily make electromagnets. The area of magnetism and electricity in a program of instruction in science gets an early introduction into the elementary school through play with toys. Electric switches, electric motors, electric trains, and all kinds of tricks that use the principles of magnetism and electricity soon make their appearance and are constantly in evidence thereafter in the intermediate school.

Mechanical toys of many kinds are common. Dump trucks, tops, steam engines, balancing clowns and monkeys, construction

sets and tools make use of levers, inclined planes, wheels, the forces generated by electric currents and by steam, the forces of gravity and tension, and almost any simple machine or principle that appears in mechanics even on the college level.

Toys that use the principles of light, sound, and chemical combinations are frequently among the most interesting possessions which children bring to school to share with others. Prisms, musical instruments, cameras, radio sets, colored pencils, kaleidoscopes, periscopes, microscopes, sets of chemicals and apparatus for experiments in chemistry and many others are among them.

It is true that the chief object of the toymaker and of the child is profit from interesting play. This does not prevent toys from being used for their contribution to the teaching of science. As in the use of all resources of a community, the teacher must be the judge of the level of individual child growth and development for the best use of any toy and the scientific principle which it illustrates.

Abraham Raskin, Assistant Professor of Biological Sciences and College Examiner, University of Chicago, has pointed out the usefulness of simple toys in teaching science.[2] He lists the following more obvious ways in which toys can be used in the program of instruction in the elementary school:

1. To emphasize the need for developing real understanding
2. To introduce the development of a generalization or a concept
3. To demonstrate the application of a principle
4. To use in the development of a generalization or a concept
5. To serve as convenient motivating devices.

The following toys listed by Mr. Raskin were chosen for use on the elementary level and are readily available in most areas. Mr. Raskin in his article gives the manufacturer, the distributor, and the price of most of the toys he lists. He points out that the classification he has used is for convenience and is in no way an attempt to organize a course of study or to suggest a teaching

[2] Raskin, Abraham, "Toys Useful In Teaching Science," *The Science Teacher*, April 1951, National Science Teachers Association, Washington, D. C. pp. 151–154.

situation. The subjects used for purposes of classification are not necessarily indicative of areas for instruction in science which should appear in the planned program for the elementary school. The subject of science and the names of toys Mr. Raskin lists which can be used to illustrate it are given herewith:

Light: Polaroid lens, tank prisms, flip movies, kaleidoscope.

Air: sail-me trick flying airplane, helicopter, boomerang, football inflator, combination sink and pump, heavy rubber football.

Sound: humming lariat, whirling whistler, string telephone, blow-a-tune, silent dog whistle.

Water: pearl diver, magic skaters, ever-drinking bird, mystery diver.

Magnetism and Electricity: electric motor kit, American magnetic electric acrobat set, gremlins, dot-n-dash set, catch-a-fish, King Tut, mystoplane, radio detector, atomic energy circus.

Simple Machines: cookie and pastry tool, automatic window catch, toy egg beater, toy rolling pin, little fella scissors, nut cracker, furniture caster, double cone, assorted pulleys.

Energy and Forces: sundial wrist watch, gyroscope, jet queen boat, cum-back, jet auto, pop-pop boat, jitter beans, spring top, magic airplane, jet-propelled balloon, walking penguin, jet boat, jet plane.

Weather: faun forecaster (hygrometer), elite weather forecaster (barometer), rain gauge, thermometer.

Miscellaneous: simple microscope, magnetic compass, magnifying glass, developing kit.

Playground Apparatus and Other School Equipment

The schoolgrounds and building are ever-present community resources which can be used in teaching science. Many primary-school teachers use trips of exploration to the school grounds and to different parts of the school building to give children security in a new environment. Many of the items which are observed on such trips will already be familiar to the children from experiences at home. The school cafeteria and kitchens are similar in many respects to kitchens and dining rooms at home. Methods of heating and lighting the building may be similar to those in

use at home. Other examples may be found to invite comparison and to give confidence.

Playground apparatus such as sandboxes, swings, seesaws and ladders are likely to be known. The schoolroom itself contains many generally familiar pieces of equipment. Thermometers, pencil sharpeners, window shades and rollers, paste, paints of many kinds, pencils, ink, electric light switches, books and a host of other objects and pieces of equipment are present and all can be used to lead into understanding science. The teacher and pupils would find them conveniently at hand to illustrate many facts and principles or to stimulate questions.

Poster paints run down a slanting easel if they are laid on too generously. The force of gravity is at work. Water used to wash the blackboards quickly evaporates from sunny spots and more slowly from dark corners. Chalk wears out and must be replaced. Friction is operative. A pitch pipe is changed to secure different tones. The use of scissors and other tools illustrates simple machines in action.

The foregoing objects and activities that are found in many schools all illustrate how resources that are close at hand in school may be used in the teaching of facts and principles of science. Happenings in the classroom or on the school grounds and in the school building may, of course, not be used to contribute to a program of instruction in science. It depends upon the teacher. In the same way, happenings at home or equipment in the home may be used to make understanding of the applications of science more vivid, or they may be entirely neglected to the detriment of learning. Parents as well as teachers have obligations to meet.

Pets and the Teaching of Science

Pets furnish one of the best media for teaching the facts and principles of science related to living things. They move and grow. They need food, water and exercise. They must be given suitable homes and cared for in other ways. They reproduce themselves and often have been changed by man in accordance with his wishes. They are affected by seasonal changes. Understanding of all these factors in the life histories of pets leads to a

general understanding of growth, changes, reproduction, characteristics and needs of animal life.

Pets are in every community. They can be observed in different classrooms at school, near homes, and in pet shops. Under proper guidance small children begin to appreciate pets through caring for them. The lives of pets are related to lives of other animals in the community. Human growth and development is understood better from many contacts with the growth and development of pets. Older children increase their understanding of growth and development through variations in the kinds of pets they care for and observe and through experiments in feeding white rats, hamsters or chickens.

Keeping pets indoors or outdoors brings many facts and principles of science close to children. Through doing it, children's interests are usually paramount, curiosity is stimulated, firsthand observations are facilitated and practical applications of science are seen in operation. If experiences with pets are kept on increasingly extended levels, the program of instruction in science will show equally increasing effects. No teacher can afford to neglect the possibilities which are close at hand or can be easily enlarged.

Increasing Possibilities of Community Resources

The possibilities for using pets, which are community resources, can be enormously increased if some imagination and effort are used by the teacher and if pupils' interests and curiosity are given sway. Two more examples will serve to emphasize the point that many resources of the community may be increased with great advantage to the program of instruction in science in the elementary school.

Birds are common, even in crowded cities. Feeding trays placed on the window sill at school will bring more pigeons, English sparrows and starlings and add to the possibilities for observation. Feeding trays may be varied in design, and making them brings also its accretion to learning science. Bird baths and bird houses also may be varied in design and made by pupils. Each of them brings to the observation of birds in the community increased possibilities and added opportunities for learning. If the

school is located in the suburbs of a city or in small-town and rural areas, bird baths and bird houses as well as feeding trays may lead to greater appreciations of bird life and to possibilities for hobbies. Differences in feeding habits and changes in bird population due to changes in conditions of weather and to seasonal changes can be observed more extensively. The resources for studying birds can clearly be increased by forethought and effort.

Gardens of one kind or another exist in every community. In crowded cities the only ones in evidence may be in window boxes. Window boxes may be used in windows at school. Pots and planting frames may be used inside classrooms. Some classrooms have potted plants. A careful survey of any community, however, will usually bring to light a garden space, wild or cultivated, which can be observed or even used for experiments in growing plants. School gardens in communities where there is room for them would bring opportunities for learning science over and above the opportunities provided by farms and gardens around the homes in the community. In some communities there are greenhouses that can be used for observations. Small greenhouses at school or dish gardens of varied kinds could be used to extend even those possibilities. The growth of plants from seeds, the need of plants for water, sunshine and food, and parts of plants may be observed and experimented with in window boxes or pots as well as in real gardens that are in the community. Such observation and experimentation is an obvious extension of the resources of any community. Landscaping school grounds, planting trees on Arbor Day, and, of course, making a collection of pictures of plants and gardens for use on a bulletin board would all extend the resources.

Extensions of the possibilities for using resources of the community have advantages for learning. Children must do something to bring them to pass. Setting up bird-feeding stations, making bird baths and bird houses, landscaping school grounds, planting a school garden, and arranging dish gardens and window boxes require effort. If interest brings the effort, then learning is likely to occur. Making models of different kinds of homes or of buildings, making a doll house and furnishing it, lighting

a play city or a doll house, setting up some dioramas, making collections, arranging bulletin boards, and many kinds of activities are often engaged in to extend the resources of a community. All are activities that should be fostered.

Trips to Places in the Community

The foregoing illustrations of science possibilities in the community are not in the least exhaustive, but, rather, illustrative. Not mentioned, but very definite possibilities, are trips to study architecture or construction on a new house, to observe seasonal change in nature, to obtain needed material from a nearby store, to see a child's garden or pets or workshop, to collect interesting stones or leaves or samples of building materials, to investigate the effects of a heavy rain as to soil erosion or drainage and nurture of growing things, to watch a neighboring farmer use a new farm machine, to see a newborn calf, to watch a steam shovel at work. That the possibilities are limitless is well illustrated by this list of places that offer possibilities which have not been explored in detail: the historical museum, wholesale house, cannery, railroad station, dairy farm, lumber yard, stone quarry, paint shop, art museum, post office, model home, department store, radio station, super market, shoe factory, waterworks, apartment building, and many others.

Resource People in the Community

In every community are people who have special interests or who have done interesting things which they will be pleased to share with children in school. These resource people may be used in a variety of ways. They may be called upon to share wide general information with the children. They may come to school to give specific information about some particular scientific process or phenomenon. There may be among them people who will have interesting educational exhibits or collections which they will be happy to share with the children. Engineers, weather men, doctors, nurses and mechanics are usually willing to help the teacher in any way they can. A visitor from the community should not be asked to make a contribution to the efforts of the class until the children and teacher alike are well aware of the

purpose of the visit. The relationship of the children to their visitors should be thoroughly understood in advance, so that the activity or experience will be pleasant and profitable.

Summary

Three ways of using community resources have been discussed: 1. We may take the children into the community and use the resource where we find it. 2. We may bring the community resources into the classroom. 3. We may bring people of the community into the schools to work with children. These, of course, are not mutually exclusive, and a combination of the three may frequently be used. Effective application of these ways of using community resources makes the task of helping children understand science a much easier one. A wealth of concrete material, rich direct experiences, various approaches to learning, and development of powers of observation are advantages to be gained.

Effective planning is basic to all profitable uses of community resources. The plans for all the learning experiences should be developed jointly by the teacher and the children. It is advisable that some record be made of these plans. Perhaps the record will be made at the blackboard by the teacher or some representative of the class. The plans should include the purpose of the learning experience. For example, if it is a trip, the plans may be similar to this: "Our Plan for Trips" may be the heading. The children would have items under the heading, such as: "What We Want to Find Out"; "What to Look For"; "Where to Go"; "What to Take"; "What to Collect"; and before their final recording of the experience, a section on "What We Found Out" should be added. The teacher and children should give some particular attention to the problem of safety if there is any danger involved, e.g., contact with irritating plants or crossing busy intersections on trips. Opportunity to participate in such planning should be a routine part of classroom procedure.

Increasing Your Understanding

1. Make a list of the resource people in your community that could contribute to the science program of the elementary school. Explain in detail the nature of the contribution you would expect from each one of these people.

2. Make a survey of the elementary schools in your community to determine the extent to which the resources of the community are an integral part of the school program.

3. Do you feel that there are some communities that are so barren of possibilities that it would not be profitable to take school excursions? Justify your answer.

4. Make a survey of the resources for science teaching to be found within one block of your school system.

5. Make a list of five experiments, suitable to the elementary school, which can be performed with apparatus you could bring from home. List the apparatus with each experiment.

6. What facts and principles could be explained more clearly as the result of a trip to a lumber yard, a super market, or printing shop? Choose one. Make the trip and list facts and principles.

7. Make a list of five questions with implications for science which might lead to a trip to a railroad station.

8. Bring three simple toys and be prepared to show in what connection or connections they might be used to explain science.

9. Make a detailed survey of your classroom or a room at home to show how it could make the teaching of science more meaningful. List the areas of science to which each item would contribute.

Additional Readings

Blough, Glenn O. and Huggett, Albert J., *Elementary-School Science and How to Teach It*, The Dryden Press, 1951. pp. 64–68.

Craig, Gerald S., *Science for the Elementary-School Teacher*, Ginn and Co., New York, 1947. pp. 31–32, 37–38, 47.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 87–92, 118–125.

Pitluga, George E., *Science Excursions into the Community*, Bureau of Publications, Teachers College, Columbia University, New York, N. Y., 1943.

The National Elementary Principal, Thirty-second Yearbook, *Science for Today's Children*, National Education Association, Washington, 1953. pp. 165–202.

Chapter 9

Equipping the Schoolroom for Science

TEACHERS need materials with which to do their work. A chief defense that can always be presented for not carrying out an effective program of science in the elementary school will be a lack of adequate materials. Instruction cannot be given without apparatus, books, and other materials, and teachers are right to make demands for supplies of all of them.

The demand for expensive, store-bought apparatus and audio-visual aids should not be allowed to interfere with the program in science, for much apparatus and practically an unlimited supply of natural science materials can be secured from almost any environment as has been pointed out. Many educative values are inherent in finding or making much of the apparatus that can be used. Teachers need to be helped in making plans for equipping their schoolrooms for science.

All those who are eager to give elementary-school children an introduction into method used in scientific thinking and into an understanding of the world of science should feel an obligation to show how the lack of much store-bought apparatus and other expensive materials need not be handicaps to an effective program of instruction in science. Inexpensive materials can be secured easily, and much apparatus that costs nothing at all can be collected. (See Chapter 8.) There is a decided advantage in helping elementary-school boys and girls collect apparatus and specimens from the environment. It adds to the interest in what is to be done; it gives a better understanding of an environment; and it makes the apparatus or the specimens more real.

Apparatus

Although kits of scientific apparatus are convenient and can be purchased, they should be bought only after the teacher and pupils have done as much as possible to supply from their environment the apparatus and the materials which they need for experimentation. If apparatus and materials are bought in advance to meet the needs of any year in science, there will be no justifiable objection to carrying on the program of science because of lack of them, but occasions for valuable learning will be lost.

In most elementary schools of the United States, science is taught in the regular classroom and by the typical teacher. Equipping the classroom for science instruction may be accomplished without placing a great burden on the teacher or the administrator. A large investment in apparatus and materials is undesirable. The science experiences for boys and girls of the elementary school are simple and do not require complicated or expensive apparatus.

Simple materials and apparatus are suggested for several reasons: (a) complicated apparatus may cause attention to be focussed upon the apparatus rather than the science principle being shown, (b) complicated apparatus cannot be manipulated easily by children, thus denying them the opportunity of learning through doing, (c) complicated apparatus is usually expensive and hence not available to many schools, (d) many of the great truths of science were first discovered by man through using simple materials, (e) simple materials, especially those that may be found in or about the home, may be used by children at home and in the school for further experimenting and exploration, (f) students are usually unafraid to try things with simple materials as it is not necessary to master new manipulative skills.

One of the outcomes which should result from all instruction is that of developing resourcefulness on the part of the learner. The program of science instruction may contribute to this idea. Boys and girls should be encouraged to find, devise, and utilize the materials they have at hand to answer their problems in science. It has been found that students who contribute materials or devise apparatus for answering a problem have a high degree

of interest in their work. The boys and girls in school are denied a valuable educational experience when they are not afforded the opportunity of locating, adapting, and using materials of their environment to solve their problems. The idea does not imply that the school has no obligation for providing some science materials and apparatus as suggested by this list.

TEACHING MATERIALS COMMONLY RECOMMENDED FOR ELEMENTARY SCIENCE BY THE TWENTY-FIVE SOURCES SURVEYED[1]

1. Tools
2. Heat source
3. Copper wire
4. Dry cells
5. Magnets
6. Magnifying glass
7. Thermometer, room
8. Bottles
9. Glass plates
10. Jars, assorted
11. Pans and trays
12. Test tube
13. Tumblers
14. Animals in school
15. Candles
16. Flashlight
17. Flower pots
18. Glass tubing
19. Iron filings
20. Rubber tubing
21. Stopper, cork
22. Terraria, aquaria
23. Alcohol, denatured
24. Iodine
25. Dishes
26. Seeds, bean, pea
27. Balloons
28. Compass
29. Electric bell
30. Tuning forks
31. Salt, table
32. Cloth, silk, wool
33. Electric switches
34. Funnels
35. Stoppers, rubber
36. Tin cans
37. Baking soda
38. Lime, slaked
39. Sugar
40. Vinegar
41. Needles, assorted
42. Prism, triangular
43. Wire, iron
44. Balance, spring
45. Balls, large, small
46. Boxes, assorted
47. Cardboard
48. Cord or twine
49. Flasks, pyrex
50. Globe, world
51. Lamp chimneys
52. Matches, safety
53. Paraffin, sealing wax
54. Plants, potted
55. Flashlight bulbs
56. Electric sockets, small
57. Microscope and slides
58. Mirrors
59. Bulbs, flowers
60. Metal, copper sheet
61. Paring knife
62. Barometer
63. Bolts
64. Cages, animal
65. Starch
66. Clay, modeling
67. Electric lamp cord
68. Teakettle
69. Thermometer, clinical
70. Cellophane, colored
71. Household ammonia
72. Beakers
73. Litmus paper
74. Pump, bicycle
75. Rock collection
76. Rubber rod or comb
77. Screws
78. Tacks, carpet
79. Ant house
80. Cup, metal
81. Electric motor
82. Iron stands; clamps
83. Lumber
84. Machines; toys
85. Pulleys

[1] Hubler, Clark, "Teaching Materials for Elementary School Science," *Science Education*, XXXIV (October 1950). p. 223.

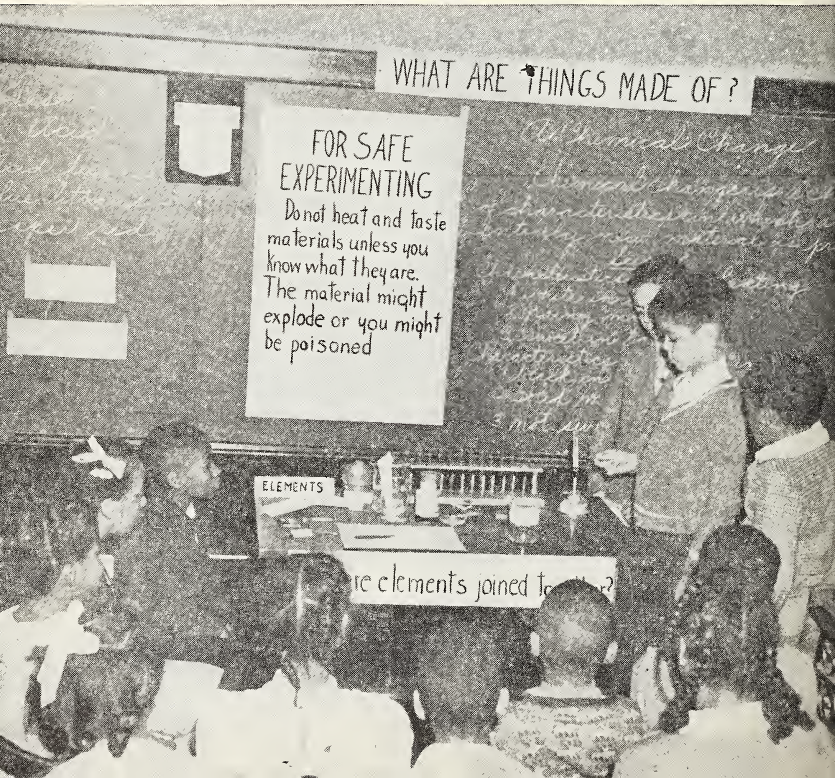
The apparatus and materials needed in a classroom depend upon the method of instruction used by the teacher. When emphasis is placed upon the problem-solving technique and experimentation, more materials and apparatus will be needed than when students experience science vicariously.

Special science equipment not readily available in the community may be obtained from science supply houses. Your high-school science teacher usually has a catalog of such supplies. Science kits have been assembled for use by elementary boys and girls.[2]

[2] Science kits are obtainable from the following sources: The W. M. Welch Scientific Supply Company, Chicago, Ill.; Standard Science Supply Company, Chicago, Ill.; Science Kit, Tonawanda, New York.

For safe experimenting, it is wise to discuss with the children what is safe and what might be dangerous and summarize their statements in a constant reminder.

Louisville Public Schools, Louisville, Ky.



Safety in Using Materials

A teacher of elementary science is concerned with safety of students as they have science experiences. The greatest number of accidents in the environment of a person occur in the home where the person is surrounded with the apparatus and materials necessary for living.

Care needs to be exercised when using simple materials in the classroom that children are not burned, cut, or injured in other ways. In general, it is wise not to use strong caustics (lye) or acids in performing experiments in the elementary school. Dangerous poisons should be avoided. Caution must be exercised in handling flames and discarding struck matches. Even with simple materials, accidents can happen if insufficient care is taken.

The teaching of elementary-school science involves very few dangers to the students if moderate caution is followed. These cautions are those that every person heeds in everyday living. Additional precaution should be taken to protect school furniture and floors not finished to withstand chemicals and excessive water against unnecessary damage.

Books of Science

Books are as essential to effective instruction in science as apparatus is. Catalogs of publishing companies and lists of books furnished by libraries and associations show such treasures of books of science for children that it seems almost foolhardy to suggest a selection among them. Since most schools, however, cannot secure all of the desirable books that have been published and would be valuable for the program of science, teachers and others must make selections. Paul E. Kambly has published yearly since 1944 in *School Science and Mathematics* a list of Reference Books of Elementary-School Science. New books for each year are listed.

On the following pages are lists which are suggestive merely of the type of books with science content which might be included in a room or school library. A brief description accompanies each title. These lists can and should be changed in accordance with the desires of teachers and children in any particular school.

Ashbrook, Frank G., *Furry Friends*, U.S. Dept. of Agriculture. Colored photographs of fur animals of North America.

d'Aulaire, Ingri and Edgar, *Animals Everywhere*, Doubleday, Doran and Co., Inc. Picture book of wild animals.

Beskow, Elsa, *Pelle's New Suit*, Harper and Brothers. How clothes are made from sheep's wool.

Burgess, Thornton W., *Flower Book for Children*, Little, Brown and Company. Reference material for a field trip. Good illustrations.

Deming, Edwin Willard, *American Animal Life*, Frederick A. Stokes Co. Descriptions of American animals. Colored pictures.

Ditmars, Raymond L., *Twenty Little Pets from Everywhere*, Julian Messner, Inc. Attractive pictures of little animals.

Duplaix, Georges, *Animal Stories*, Simon and Schuster, Inc. Delightful short stories about tame and wild animals.

Flack, Marjorie, *The Restless Robin*, Houghton Mifflin Co. A study of all well-known birds of U.S.

Gag, Wanda, *The A.B.C. Bunny*, Coward-McCann, Inc. A sentence or two beginning with each letter in the alphabet pertaining to science.

Gag, Wanda, *Nothing At All*, Coward-McCann, Inc. Story of an invisible dog.

Hall, Marie, et al, *In the Forest*, The Viking Press. A little boy's imaginary animal friends in the forest.

Krauss, Ruth, *The Happy Day*, Harper and Brothers. The animals' joy in the coming of spring.

Lathrop, Dorothy P., *Who Goes There?*, The Macmillan Co. Story of smaller forest creatures—chipmunks, squirrels, porcupines, rabbits and mice.

Lord, Isabel Ely, *The Picture Book of Animals*, The Macmillan Co.

McCloskey, Robert, *Make Way for Ducklings*, The Viking Press. Life story of ducks and ducklings.

Meyer, Jerome S., *Picture Book of Astronomy*, Lothrop, Lee and Shepard Co., Inc. Astronomy study—to be read to class by teacher or used as reference.

Newberry, Clare Turlay, *Pandora*, Harper and Brothers. Attractive story and illustrations of a kitten.

Pistorius, Anna, *What Butterfly Is It?*, Wilcox and Follett Co. A reference book of butterflies. Good for field trip.

Pyne, Mable, *The Little History of the U.S.*, Houghton Mifflin Co. Third Grade. Good for noting differences in parts of U.S.

Ray, H. A., *Elizabite*, Harper and Brothers. The adventures of a carnivorous plant.

Seus, Dr., *Thidwick*, Random House. The story of a big-hearted moose.

Seus, Dr., *McElligot's Pool*, Random House. Excellent primary study of fish.

Smith, E. Boyd, *Chicken World*, G. P. Putnam's Sons. Story of barnyard fowls; also study of changing seasons.

Smith, E. Boyd, *So Long Ago*, Houghton Mifflin Co. Picture story of prehistoric animals. Third Grade.

Stilwell, *ChinLing, the Chinese Cricket*, The Macmillan Co.

Tresselt, Alvin, *White Snow, Bright Snow*, Lothrop, Lee and Shepard Co., Inc. Picture book about snow and how it affected different people.

The Second Picture Book of Animals, from Photograph Collections of *Das Tier*, The Macmillan Co. Actual photographs of wild and domestic animals.

For the Intermediate School

Brindage, Ruth and Carter, Helene, *The Story of Our Calendar*, Vanguard Press.

Bronson, Wilfrid S., *Fingerfins, the Story of a Sargasso Fish*, The Macmillan Co. Gds. 4–5.

Bronson, Wilfrid S., *Horns and Antlers*, Harcourt, Brace and Co. Gds. 5–6.

Bronson, Wilfrid S., *Paddlewings, the Penguin of Galapagos*, The Macmillan Co. Gds. 4–6.

Bronson, Wilfrid S., *Pollwiggle's Progress*, The Macmillan Co. Gds. 4–5.

Bronson, Wilfrid S., *The Chisel Tooth Tribe*, Harcourt, Brace and Co. Gds. 4–5.

Bronson, Wilfrid S., *The Grasshopper Book*, Harcourt, Brace and Co., Inc. Gds. 5–6.

Bronson, Wilfrid S., *The Wonder World of Ants*, Harcourt, Brace and Co., Inc. Gds. 4–6.

Buff, Mary and Conrad, *Big Tree*, The Viking Press.

Ditmars, Raymond and Carter, Helene, *Insect Oddities*, J. B. Lippincott Co. Gds. 5–6.

Du Puy, William Atherton, *Our Animal Friends and Foes*, The John C. Winston Co.

Du Puy, William Atherton, *Our Bird Friends and Foes*, The John C. Winston Co.

Du Puy, William Atherton, *Our Insect Friends and Foes*, The John C. Winston Co.

Du Puy, William Atherton, *Our Plant Friends and Foes*, The John C. Winston Co.

Floherty, John J., *Guardsmen of the Coast*, Doubleday, Doran and Co. Gds. 4–5.

Freeman, Mae and Ira, *Fun with Chemistry*, Random House. Gds. 5–6.

Freeman, Mae and Ira, *Fun with Science*, Random House.

Gaer, Joseph, *Everybody's Weather*, J. B. Lippincott and Co. Gds. 4–5.

Huey, Edward G., *What Makes The Wheels Go Around*, Reynal and Hitchcock. Gds. 6–7.

Kane, Henry B., *The Tale of the Whitefoot Mouse*, Alfred A. Knopf, Inc. Gd. 4.

Lent, Henry, *Diggers and Builders*, The Macmillan Co. Gds. 4–5.

Lent, Henry, *Wide Road Ahead*, The Macmillan Co.

Medsoer, Oliver P., *Nature Rambler, Spring*, Frederick Warne and Co., Inc. Gd. 5.

McCracken, Harold, *The Biggest Bear on Earth*, Frederick A. Stokes Co.

Patch, Edith and Fenton, Carroll, *Holiday Shore*, The Macmillan Co. Gds. 4–6.

Pease, Josephine and Friend, Esther, *It Seems Like Magic*, Rand McNally and Co. Gds. 4–6.

Petersham, Maud and Miska, *The Story Book of Earth's Treasures*, The John C. Winston Co. Gds. 4–5.

Reed, W. Maxwell, *And That's Why*, Harcourt, Brace and Co., Gds. 4–6.

Shakelford, Shelby, *Now for Creatures*, Charles Scribner's Sons. Gds. 5–6.

The Bird Book, Junior Press Books, Albert Whitman and Co.

Williamson, Margaret, *The First Book of Bugs*, Franklin Watts, Inc. Gd. 4.

Books for Identification in Science Areas

A major difficulty connected with meeting adequately the incidental happenings that have significance for science is identification of specimens. The child may at any time on any day bring a specimen of rock, insect, feather, nest, flower, leaf, plant, seed, shell, or other object found in the environment and demand, "What is it?" No teacher can possibly make preparation for knowing everything, even a specialist in entomology will often have to say, "I don't know," when specimens of insects are presented. This is not strange, for there are over 200,000 species of known insects and probably a total number ranging to well

over twice that number. The best that can be done is to accumulate little by little an acquaintance with common birds, flowers, rocks, minerals, trees, and insects. Each school library should contain these or similar books for identification of specimens.

I. General

Comstock, Anna B., *Handbook of Nature Study*, Comstock Publishing Company, Ithaca, New York.

II. Birds

Bailey, F. M., *Handbook of Birds of the Western United States*, Houghton.

Hoffman, Ralph, *Birds of the Pacific States*, Houghton.

Peterson, R. T., *Field Guide to Western Birds*, Houghton.

Pearson, T. G., Brimley, C. S., and Brimley, H. H., *Birds of North Carolina*, Edwards and Broughton Printing Co., Raleigh, N. C.

Roberts, Thomas Sadler, *Bird Portraits in Color*, University of Minnesota Press, Minneapolis, Minn.

Green, Charlotte Hilton, *Birds of the South*, University of North Carolina Press, Chapel Hill, N. C.

Pough, Richard H., *Audubon Bird Guide*, Doubleday and Co., Inc.

III. Chemistry

Brownlee, Raymond B., Fuller, R. W., Hancock, W. J., and Whitset, J. E., *The Chemistry of Common Things*, Allyn and Bacon.

Morgan, Alfred P., *Boys Book of Science and Construction*, Lathrop, Lee and Shepherd Co., Inc.

Freeman, Mae and Ira, *Fun with Chemistry*, Random House.

IV. Flowers

McCurdy, Robert M., *Garden Flowers*, Doubleday, Page and Co., for Nelson Doubleday, Inc.

The Book of Wild Flowers, The National Geographic Society, Washington, D. C.

Mathews, F. Schuyler, *The Book of Wild Flowers for Young People*, G. P. Putnam's Sons.

Hausman, Ethel Hinckley, *The Illustrated Encyclopedia of American Wild Flowers*, Garden City Publishing Co., Inc., Garden City, N. Y.

V. Insects

Swain, Ralph B., *The Insect Guide*, Doubleday and Co., Inc.

Teale, Edwin Way, *The Boys Book of Insects*, E. P. Dutton and Co., Inc.

Williamson, Margaret, *The First Book of Bugs*, Franklin Watts, Inc., New York, N. Y.

Our Insect Friends and Foes and Spiders, National Geographic Society, Washington, D. C.

Matschat, Cecile H., *American Butterflies and Moths*, Random House.

VI. Rocks

Williams, Henry Lionel, *Stories in Rocks*, Henry Holt and Co.

Loomis, Frederick Brewster, *Field Book of Common Rocks*, G. P. Putnam's Sons.

Whitlock, Herbert P., *The Story of Minerals*, The American Museum of Natural History, New York, N. Y.

VII. Shells

Guberlet, Muriel Lewin, *The Seashore Parade*, The Jaques Cattell Press, Lancaster, Penn.

Richards, Horace G., *Animals of the Seashore*, Bruce Humphries, Inc., Boston, Mass.

Verrill, A. Hyatt, *Shell Collector's Handbook*, G. P. Putnam's Sons.

VIII. Snakes

Ditmars, R. L., *Snakes of the World*, The Macmillan Co.

Pope, C. H., *Snakes Alive*, The Viking Press.

Zim, Herbert S., *Snakes*, William Morrow and Co.

IX. Trees

Green, Charlotte H., *Trees of the South*, University of North Carolina Press, Chapel Hill, N. C.

Coker, W. C. and Totten, H. R., *Trees of the Southeastern States*, University of North Carolina Press, Chapel Hill, N. C.

Collingwood, G. H., *Knowing Your Trees*, American Forestry Association, Washington, D. C.

Hough, R. B., *Handbook of the Trees of the Northern States and Canada*, Harper Brothers.

Preston, R. J., *Rocky Mountain Trees*, State College Press, Ames, Iowa.

X. Stars

McKready, K., *A Beginner's Guide to Stars*, G. P. Putnam's Sons.
Neely, H. M., *Primer for Star-gazers*, Harper Brothers.
Olcott, William T., *A Field Book of the Stars*, G. P. Putnam's Sons.
Pickering, J. S., *The Stars Are Yours*, Macmillan.
Wylie, C. C., *Our Starland*, Lyons and Carnahan.

Periodicals

Current magazines and newspapers make peculiarly valuable contributions to the program of science, and elementary schoolrooms and libraries should be supplied with some of them. They stir up interest in current topics and give a supply of illustrations.

This is a list that can be recommended in making selections:

1. *Bird Lore*. Bi-monthly. Devoted to the study of birds and mammals.
2. *Popular Science Monthly*. Monthly.
3. *Science News Letter*. Weekly. A useful digest and readable journal of scientific news in general.
4. *Current Science*. Weekly during school year. Classroom use.
5. *Nature Magazine*. Monthly. An official organ of American Nature Association. Purpose: to stimulate interest in out of doors.
6. *Natural History*. 10 months. Timely articles on birds and animal lore as well as life and customs of people and countries in the news today.
7. *Junior Natural History Magazine*. Monthly. Contains much information in story form with clear and winning illustration.
8. *Outdoor Life*. Monthly. Sportman's magazine, hunting, fishing, camping, dogs, photography, boating.
9. *Life*, Science Section. Weekly.
10. *All Pets*. Monthly. Articles on feeding and training of pets.
11. *Aviation*. Aero Digest. Monthly.
12. *Boy's Life*. Monthly.
13. *Popular Mechanics*. Monthly.
14. *Science Digest*. Monthly.
15. *Weekly Star Map*. Weekly.
16. *My Weekly Reader*. Weekly.
17. *National Geographic Magazine*. Monthly.
18. *Young America*. Weekly. Usually carries a section on science.
19. *Boy Scout Handbook*.

Tools and Materials for Construction

Every classroom should have a workbench and tools such as hammer, saw, screwdriver and plane. For many classrooms they will not be provided and the teacher must resort to makeshifts with tools brought from home, borrowed at school or the school workshop. The tools and workbench do two things for the science program: they show inventions being used in work and they are needed for constructing homemade apparatus.

Every schoolroom should be supplied with wood, paper, paste, clay, and the materials commonly used for constructive and creative work.

Audio-Visual Aids

Audio-visual aids should be available for the program of science in the elementary school. The subject is covered in Chapter 10.

General Classroom Set-up

Heat

Frequently a source of heat is needed for some science experiences. An electric hot plate may be used safely by elementary boys and girls. Many schools have gas hot plates or a gas stove on which experiments needing heat may be used. Several types of "canned heat," which usually consist of a solid in a can, may be used as a satisfactory source of heat.

Stoves and radiators used to heat the classroom are suitable as a source of heat for some science experiences. An alcohol lamp provides a smokeless flame. A large electric light bulb gives off considerable heat and could be utilized for warming certain things. Hot water as a source of heat should not be overlooked.

Water

More and more, the elementary classrooms are being provided with sinks and running water. However, there are many classrooms without running water. Science experiences can be carried on by using buckets, dish pans, large jars, and cans as containers for water. Water can be heated in pans or cans. If it is necessary

to heat water in a visible container, heat-resistant nursing bottles, dishes, and coffee makers can be used.

Aquariums

Every classroom should have an aquarium, but one that adds to previous experiences. It may be a thing of beauty as well as an excellent place to teach many plant and animal relationships. A well-planned aquarium represents a complete environment.

Aquariums can and should be varied for each year. In the first year, it is enough if the aquarium has a few goldfish, some plants and a rock or two to add interest. From then onward, the animal inmates of the tank and the arrangements of plants and other objects should show progress in interest and understanding. Snails might be added the second year. Perhaps a tropical fish habitat might be arranged in later years. If the same kind of aquarium is set up year after year, all possible learning will soon be achieved and boredom will set in. Variety might be secured by setting up along with the main aquarium some smaller bowls in which water creatures might be kept.

The main aquarium in the classroom should be large enough to hold four to five gallons of water. It should be rectangular in shape rather than cylindrical, and it should contain plant and animal life.

There is also a need for a number of small aquariums for keeping certain living things for short periods of time or for special purposes. These aquariums may be made from various sizes of glass jars.

Some science concepts that may be taught by using an aquarium are:

Some plants live in water.
Some animals live in water.
Some animals that live in water are streamlined.
Water evaporates into the air.
Water contains dissolved air or oxygen.
Fish have special organs for moving through the water.
Fish have special organs for removing dissolved oxygen from water.

Plants need sunlight to grow.
Animals get food from plants.
Some animals lay eggs.
Some animals give birth to their young.
Fish move by swimming.
Fish breathe air.
Fish have gills.
Some fish have scales.
Fish can see.
Plants grow at their ends.
Plants and animals depend upon each other.
Changes in temperature affect life in the aquarium.
Green plants give oxygen to the water.
Animals remove oxygen from the water.
Animals give carbon dioxide to the water.
Plants remove carbon dioxide from the water.
Animals need food to live.
Plants need food to live.
Roots of plants grow down.
Stems of plants grow upward.
Polluted water kills life.

Teachers may provide their pupils with a good learning experience by allowing them to set up their own well-planned fresh-water aquarium. Here are some helpful suggestions:

Materials That Are Needed

1. A large tank with glass sides. The tank should be longer than it is wide. It should be about a foot deep. The glass should be cleaned with clear water and a cloth or a sponge. Soap or cleaning liquids and powders may be harmful to the plants and animals that will be placed in the aquarium.
2. Some clean sand for covering an inch or more of the bottom of the tank. The sand will hold the plants in place and give them some food for growing.
3. Some stones to hold the sand and plants in place and to make the aquarium more interesting.
4. A small net for dipping out the animals.

Murray State College Training School, Murray, Ky.

Sterilizing the sand and rocks to put into the aquarium being set up is a good project for a third-grade group.

5. A rubber tube or a bent-glass siphon for helping to keep the aquarium clean.

6. A pitcher and a pan for pouring fresh water into the aquarium.

7. Four or five pieces of plants that grow in water.

8. Fish. One small fish an inch long needs more than one gallon of water. Too many fish should not be put in an aquarium.

9. Four or five snails to help keep the tank clean.

10. Clean water. If water is taken from a pipe, it should be kept in a pan or bucket for a day or two before it is used. Water for the aquarium should be about the temperature of the room before fish are put into it.

1. Be sure that the tank is clean.
2. Pour in the sand and spread it over the bottom.
3. Place the plants in the sand and place stones above the roots. If the plants have no roots, place sand and stones on the ends where roots will grow. This will hold the plants where you have put them.
4. Pour clean water into the tank. Pour the water onto a flat plate held near the sand. The water should come to about two inches from the top of the tank.
5. The tank with the water and plants and sand in it should stand for a day before you put the animals into the water.
6. Put the snails and fish into the water. Use the dipping net to lift them into the tank. It is not good for the animals to be handled.
7. Cover the tank with a clean flat piece of glass.
8. Feed the fish at first with food that you can buy especially for them. Uncooked oatmeal is a good food for fish. Do not feed fish every day. Only a small amount of food is needed.

Pupils will want to know how to tell whether or not their efforts are successful. If the aquarium has been well-planned, the plants will begin to grow, the fish will not come to the top for air, there will be little cleaning necessary, all food will be eaten and little water will need to be added.

Terrariums

Just as an aquarium represents a complete water environment, a terrarium represents a complete land environment. Terrariums may be prepared in large or small jars depending upon the kind and size of animals and plants you wish to keep in them.

There are a number of types of environments you could illustrate in a terrarium. It is possible to have a bog type terrarium, where the plants and animals are those that live in a very wet place. Or the terrarium may contain plant and animal life found in hot and dry regions. The terrarium may contain certain plant and animal life found at various elevations in your community.

Jordan School District, Sandy, Utah

The class terrarium would be a constant source of interest to some members of the class.

School children can make their own terrarium as easily as the aquarium. Teachers will find these simple directions helpful.

Materials That Are Needed

1. A glass tank like the one that is used for an aquarium:
2. A large handful of charcoal.
3. Some sand and small stones.
4. Rich, moist, wood soil. You can make wood soil by mixing one part of sand with two parts of leaf mold. Leaf mold is decayed leaves.
5. Small flat dish to hold water for a pool in the terrarium.
6. Slow-growing plants. Use different kinds of plants. Find out which ones grow well.
7. Animals such as a salamander, small land turtle, toad, land snails, and earthworms. A land turtle is called a terrapin.
8. Water enough to fill the flat dish.
9. A flat piece of clear glass for covering the terrarium.

How the Terrarium Is Set Up

1. Clean the sides and bottom of the tank or jar.
2. Put a large handful of charcoal in the bottom of the tank or jar. Charcoal keeps the soil from turning sour.
3. Cover the charcoal with a layer of sand and small stones.
4. Heat the wood soil in the oven or pour boiling water over it. The heat will kill any harmful insects or plants in the soil. When the soil is cool and dry again, put the soil over the charcoal and the sand and stones. Make one side and one end of the soil in the terrarium higher. This will make some of the soil deeper for larger plants.
5. Set the flat dish in one end of the terrarium. Fill it with water. Make the soil come up to the edge of the dish.
6. Moisten the places where plants are to be placed. Put in the plants and sprinkle them with water after they are planted.
7. Place the flat piece of glass over the tank or jar when you have put the plants in.
8. After the terrarium has stood for a week or two, the plants will begin to grow. Then put in the animals.
9. Flies and ants are good insects to use for animal food. Fruit and berries can be used for food for some of the animals.

Schoolroom Zoo

One aspect of the elementary-science program deals with the variety of animal life and animal activities. Many types of small animals may be kept and cared for in the classroom for study. The aquarium and terrarium serve as homes for some animals. Others may be kept in jars and cages. The animals kept in the classroom should be cared for; that is, properly fed and protected. Their containers must be clean. Animals selected should be able to endure the changes of temperature to which the classroom is subjected. Boys and girls readily accept the responsibilities involved in maintaining an interesting classroom zoo.

General Classroom Equipment

Since most science in the elementary school is taught in the regular classroom, one would not want to overlook the possibilities of the regular equipment for science instruction.

It is suggested that the elementary classroom for science instruction be equipped with general furniture that can be moved about easily. A good program of science instruction calls for many types of activities: experimenting, constructing, dramatizing, demonstrating, painting, exhibiting, reading, arranging, drawing, identifying, examining, observing and listening. Many of these activities are not peculiar to science instruction. There are frequently times when a rearrangement of the furniture would make for better accomplishment in the above activities if space in the classroom can be made available to accommodate the activity.

The Bulletin Board

The present-day elementary classroom has available tack board or bulletin board space. This space is excellent for displaying items produced by the boys and girls or brought in by them to be shared with the group. These include flat pictures, post cards, illustrations, paintings, charts, maps, certain exhibits, some objects and specimens, cartoons, drawings, posters, graphs, murals, summary of learnings and scientific terms. Frequent changes of the contents on bulletin boards are necessary if interest is to be maintained.

Science Table

Many teachers of science have found that a table, frequently known as a science table or science center, is valuable as a place where science materials, exhibits, specimens, objects, models, demonstrations and experiments, are displayed. This table is in a sense an experience center for children studying science, a place where firsthand experience may be obtained in seeking answers to their science problems. Most of the material on the science table should be changed frequently. This, of course, does not apply to books of identification, tools or equipment used throughout the year.

Summary

The climate of the classroom for teaching science, as for any other area of the curriculum, should be conducive to promoting

growth in children. The room should be attractive, and it should contain science objects arranged so that the child is led into wanting to learn about them. There may be pictures illustrating the science interests of the group. There may be exhibits, models, specimens, and objects with which they have been working. There may be plant and animal life which contribute to expanding the ideas children may have had. There may be a series of shelves or tables on which are kept materials used in answering science questions and solving science problems. There may be drawings, dioramas, charts, and posters illustrating processes, relationships, and activities in which boys and girls have been engaged.

Increase Your Understanding

1. Explain fully what is meant by a science corner in a classroom. What would be found in such a place? Would a science corner stimulate interest in science? How?

2. Examine a Science Kit. What apparatus does it contain that could not be secured easily in your community? What arguments can you array for buying the Kit you have examined? Are there arguments against buying it? What are they?

3. Make a list of twenty-five books of science that you would buy first for a primary school or for an intermediate school. Exclude books from any series of science texts or science readers. Exclude also books that are chiefly fictional. Include the price and the publisher of each book. Be sure to include only books that you have examined critically.

4. Recommend the best book for identifying birds; also for each of these: wild flowers, moths, insects, or rocks. Why is it the best?

5. Suggest a plan for taking care of apparatus. Why did you include children in, or exclude them from, your plan?

Additional Readings

Blough, Glen O. and Huggett, Albert J., *Elementary-School Science and How to Teach It*, The Dryden Press, 1951. pp. 60–64, 247–250.

Craig, Gerald S., *Science for the Elementary-School Teacher*, Ginn and Co., New York, 1947. pp. 36–37, 254–258.

Dowling and Others, *Understanding Science Series*, Teacher's Manuals for each of the books in the series, The John C. Winston Co., Philadelphia.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 98–101.

Parker, Bertha M., *Science Experiences*, Row, Peterson Co., 1945.

Chapter 10

Using Audio-Visual Aids in Science Teaching

The need for improved, enriched classroom instruction is universal. Neither size nor location of school or classroom negates it. In the one-room rural school, in the village school, in the large city school, there exists the problem of how to teach more effectively. Teachers may well make their important contributions in meeting our country's demand for better education by the development of a program of instruction in their classrooms which is appropriate to the needs of the boys and girls in their community and which makes full and intelligent use of all types of instructional materials. Many wide-awake elementary-school science teachers have come to recognize the potentialities for improvement in a more carefully planned and a more extensive use of audio-visual materials of instruction.

What Are "Audio-Visual Materials"?

The first question entering the mind of one just entering upon the study of how to use audio-visual materials of instruction most effectively is: "Just what does the expression 'audio-visual materials of instruction' mean?" This expression refers to those materials of teaching which are intended to bring about learning chiefly through means other than the printed or written page and the spoken word alone.

The following list includes those audio-visual materials most readily available and usable: museums, working models, dioramas, biological specimens, posters, maps and globes, graphs, diagrams, charts, cartoons, stereographs, pictorial pamphlets, photographs, phonograph records, slides, filmstrips, motion pictures, opaque projectors, textbook illustrations, snapshots, paintings, radio, television, the blackboard, bulletin board, tape recorder, field trip, dramatization. In the above list, there is no distinction made between special activities which utilize multiple-function visual materials and the visual materials themselves. The two are so closely related that there seemed to be no real gain in listing them separately.

Should Audio-Visual Materials Be Used in Teaching Science?

The answer is yes, if the use of such materials is not regarded as a panacea or a new technique which has intrinsic value that will automatically make for effective teaching. These materials furnish increased possibilities for effective instruction at all grade levels and in all types of educational experiences. Experience and research have shown clearly that wise use of these materials helps to bring about desirable learnings which do not result if these materials are ignored. One cannot emphasize the fact too strongly, however, that a careless, poorly-planned use of audio-visual materials can seriously reduce the effectiveness of teaching.

A real danger exists in an exaggerated use of commercial audio-visual aids. One can look at moving pictures, filmstrips, television shows, and exhibits prepared by industrial companies without making any effort to contribute to the learning situation. With no more effort one may listen to sound films or to television. It would be folly to deny that some learning comes from such effortless looking and listening. On the other hand, it is folly to deny that real learning comes from doing something about what is being learned. The danger in the use of commercially prepared aids is that children are inactive except perhaps mentally. The same danger is noticeable in using leisure time largely and often exclusively in attending the picture show, listening to the radio and sitting glued to television.

If activity does not go on in connection with the use of audio-visual aids, the program of science is made less effective. That is true for all aspects of the school program. Active participation by the learners is a *sine qua non.* Children should perform some experiments themselves, not merely sit and watch others perform them. They should assemble and arrange some exhibits themselves, not merely look at exhibits which have been brought to school already assembled and arranged. They should make some apparatus, not merely use apparatus which has been purchased. They should make some charts, dioramas, drawings and models, not merely look at those which others have made. They should make some of their own pictures and slides and make up some of their own dramatizations, not merely accept what someone else has contrived. No one denies that looking at a garden is a valuable experience for learning, but equally no one should deny that making a garden personally is more valuable. Audio-visual aids are valuable, but it is tragic when they are used as sedatives.

In a number of chapters throughout this book, considerable emphasis is given to the variability of the backgrounds of experience of children studying science in the elementary schools. The science experiences of a classroom take on different meanings for each individual student in the classroom, since they are based on his previous personal experiences. Children of two families within a community, or within a particular section of a community, may, quite likely, have most dissimilar backgrounds. One child may come from a privileged home which has many modern conveniences, including a variety of electrical appliances. The same child may be able to have a chemistry set. His family may be able to afford many hobbies for him which are related to science. It is quite possible that he may subscribe to *Things of Science.* He may see much science material in magazines such as *Life* and *National Geographic.* The conversation in this home may deal with many science experiences.

Another child in this same community may be quite poverty-stricken as far as science experiences are concerned. Poverty in science experiences does not necessarily correlate positively with economic poverty. Science is all about us and available to rich

and poor alike. The child's dearth of science experiences may well be, then, due to a lack of sensitivity to the world about him, as well as to a difference in material opportunity.

Whatever the cause of the differences, audio-visual materials provide a great possibility for equalizing this disparity in experiential background. Experiences which children have not had because of a lack of opportunity or those in which they have ignored such opportunity can be brought to them in the classroom through the medium of the motion picture, still pictures, or many of the other audio-visual materials. This contribution may be further increased by making it possible to overcome some limitations of normal classroom presentation. Some things are so large, some so small, some so slow, some so fast, some so complex that the usual instructional materials are not adequate for making the concepts meaningful and understandable to children. There are other restrictions of sound, climate, season and weather which visual and auditory aids may help overcome.

A beautiful and amazingly interesting sound film produced by the Walt Disney Studios, entitled "Nature's Half Acre," is a marvelous illustration of a medium which overcomes the limitations of season, climate, "too slow" phenomena, and geographic location. It captures all of the beauty and magic of nature as it shows the annual life cycle of plants and animals all over the world as they experience the four seasons in their natural habitat. Time-lapse photography shows the details of seed germination, the opening of blossoms, and many other interesting phenomena which could not be brought to the classroom in any other practical way.

Children in the elementary school may have a secret place which they visit at various seasons of the year. It is quite possible that, as they proceed on this nature hike, observing the stream, animals and birds, that they will see so much that it will be difficult to assimilate it all. There will, however, be a great deal of motivation to learn more about all of these things they have seen. Teachers should take advantage of the use of audio-visual materials to extend learnings from science trips and practical work. The following description explains how a teacher made expert use of audio-visual materials for this purpose.

Our large consolidated elementary school is in a rural community. The school grounds are subject to erosion as are farmlands in this area. Every year my class in the last year of the intermediate school has as one of its projects the control of new beginnings of erosion on the school grounds. The past year we decided to get a better understanding of the causes of erosion and of ways to control it permanently.

Our project began after a heavy downpour of rain had started new gullies on a hillside where children frequently played and had worn off most of the grass. One of the members of our class suggested that we visit a farm nearby to see how a farmer who was known to have made special efforts to save his soil had done it. We walked to the farm after finding out that the farmer was willing to have us come and that he would have time to show us around the farm and answer our questions on conservation of soil. We all took notebooks and pencils for we expected to make notes and sketches. Two members of the class took cameras for we wanted to get actual pictures to put in a large scrapbook which we almost always use to make a record of our activities so that we and our visitors can see what we have done. We use this scrapbook for reminders of what we have learned as well as of what we have done.

The farmer showed us terraces, contour plowing and planting, strip cropping, gullies that had been filled and reclaimed for crops, and fence rows that had been left overgrown with bushes and other plants to hold back water. Many questions were asked and the farmer's answers were recorded. Many new words had to be explained to us. Numerous sketches were made and the two members of the class with cameras took pictures which they thought would be helpful to us when we wanted to talk again about our trip.

On our return to the school, those who had made sketches completed them and arranged a display on the bulletin board. An immediate attempt was made by a group from the class to apply what we had learned on our trip. They planned how to stop the new erosion which the rain had begun on the grounds. The principal of our school suggested that a showing of the film, *The River*, which he had seen, would help us in understanding causes of erosion. Our P.T.A. agreed to rent the film for us. Members of the class began bringing in pictures of eroded fields. We used the school's opaque projector to project them on the screen which two boys brought to our classroom. Much discussion of how the particular type of erosion might have been

prevented resulted. The librarian at our school helped us find books and parts of books and magazines on conservation of the soil. She suggested that we order a pamphlet of which she had recently heard. The name of the pamphlet was *Muddy Waters* by Henrie Andrews Howell. It was published by Applied Economics, Inc., Winchester, Mass. We used sixty cents of our class money to order two copies. We arranged a shelf of books on conservation of soil in our science corner. Members of the class used markers to show places in the books where the subject was discussed.

In the meantime, the pictures which the two members of our class had taken on our trip had been developed. We found out how to make 2 by 2 inch slides of them and of some of the sketches which had been drawn by other members of the class. Everyone in the class, including the teacher, made at least one slide. During this time the film, *The River*, arrived, and members of the P.T.A. were invited to see it along with us. It was a most dramatic film, and some of the causes of erosion at once became more real to us. Other pupils in the school had heard of what we were doing and had come to see our bulletin board and to read our large scrapbook and to look at the pictures in it. Many of them as well as many of the pupils in our class reported that they had already started to control erosion on yards and in gardens at home. The film had to be sent back before we knew that so much interest was being shown by others and so we did not invite any pupils to see it. We did invite them to attend a showing of the slides we had made, having arranged a program on conservation (as much as we knew about it) which we gave in our classroom.

The farmer whose efforts at conservation we had studied came by invitation one noon period and helped some members of the class who wanted to do it and who were much interested in mathematics to start a contour map of the school grounds. He told us that The J. I. Case Company, Educational Division, Racine, Wisconsin, had films and booklets on conservation of soil that he thought we could borrow or rent. A committee wrote a letter of inquiry to the company. The reply came too late for us to do anything but file it in our filing cabinet for future use. The pamphlet, *Muddy Waters*, came at that time, and members of the class took turns reading the two copies. Its pictures and text were exactly what we wanted. Members of the class are now collecting money to buy individual copies.

Letter writing, oral and written reports, reading, spelling of new words related to conservation of soil, mathematics, drawing, and many oral discussions all made their contributions to control of erosion on our school grounds and at some of the homes in

> our community as well as to our general understanding of the subject. Our practical work, our bulletin boards, our slides which we showed several times and especially our scrapbook containing pictures, information and other items significant to our project became objects of general interest. Many visits by parents and children of our school to our classroom kept the subject fresh in our minds.

The foregoing description shows how a teacher and pupils made use of the potential of audio-visual materials for providing uniformity of perception, for providing motivation and stimulation through the awakening of new desires and interest, and for economical learning through integrative experiences.

Guiding Principles

In the use of any kind of instructional aids, it is necessary that the teacher know them well. It is even more important and necessary as increased use of audio-visual materials is made. Audio-visual materials are designed to assist in teaching science. It must never be assumed that they can serve as the substitute for a teacher. It is indefensible to sit back and let them take over. Teaching must be done by explaining the materials, by permitting the students to examine them, by discussing them, and by always encouraging further study. Audio-visual materials should be chosen with the same care which would be exercised in choosing any other instructional aid. They also require continuous evaluation, for they are only one stage in that long journey of effective teaching.

In using these materials for the very practical purposes of arousing pupil interest, of supplementing knowledge obtained from other sources, of enlarging the environment of an individual, of promoting intellectual curiosity, of increasing acquisition and retention of information, of achieving economy of time in instruction, and of fostering favorable attitudes, one should keep in mind these guiding principles gleaned from many sources in the literature on audio-visual materials.

1. Careful thought should be given to the selection of materials, with due regard for such factors as purpose, attractiveness, accuracy, use, propaganda and cost. These materials

should be previewed or tried out in advance of use in the classroom so that they may be judged for suitability.

2. The materials should be integrated with the curriculum.

3. You cannot merely exhibit the materials; you must teach them.

4. Do not use too many audio-visual materials.

5. Use only those materials which enrich the present experiences of the children.

6. Make the materials an integral part of effective teaching.

7. Use them in the regular classroom.

8. Materials must be factually correct.

Steps in Using Audio-Visual Materials

The following steps for using audio-visual materials will not necessarily always appear in the order suggested here. Even though this pattern will vary, it is felt that more effective teaching will result from some attention to all of these factors in every instance.

1. Select your material on the basis of a real need.

2. Study the material thoroughly.

3. Discuss the problem to be solved with your pupils and clearly relate the purpose in showing the film to the solution of the problem.

4. Use the material.

5. Make provision for a definite follow-up.

6. Teach the material again if you and the pupil feel it is necessary. It may be used for teaching purposes many times; but for entertainment, less frequent use is advisable.

7. Explore with your pupils implications for further study which grow out of the use of this material.

8. Evaluate the use of the material.

Field Trips

Field trips are made upon many occasions, not only in connection with science but in connection with other subjects of study and for many purposes. From any trip, leads into science will be found. Many trips on the other hand are made especially in connection with a program of science.

Glencoe, Illinois

After the teacher has surveyed the locality, she may take field trips to places of special, not general, interest with her group.

Trips for the sake of taking trips are wasteful of time and ineffective for learning. The same is true of seeing moving pictures or using other audio-visual aids. Firsthand contacts, however, are so important that well-planned trips and the use of audio-visual aids should be frequent in all schools.

If a field trip is to be successful, it must be carefully planned by the teacher. The pupils should have definite ideas of the purpose and should know how they should behave from the time they leave the building until they return.

The first step in a teacher's plan is a survey of the locality to be visited. She should be very sure it has something of educational value to the children. Many times groups have gone on

bird walks or trips to collect seeds and have come home disappointed without having seen a bird or a seed. Such excursions are not only a waste of time, but in all probability develop in the pupils undesirable attitudes towards trips.

Not only should the teacher assure herself that the trip is worthwhile, but she also should know the best route to take and exactly where the group should stop and what they will find. Her techniques of helping the pupils see and understand the specimens should be as carefully planned as any classroom recitation. She should know what principles can be developed and how she will attempt to develop them.

The pupils' plans should include a discussion of the purpose of the trip and how to behave on the streets in large crowds or in a group anywhere. They should realize that they should walk singly or in twos or threes so as not to obstruct the paths of those they meet. Loud and boisterous talking is conspicuous and undesirable and gives the public a bad impression of the school from which the children come. With skillful questions the teacher can stimulate the pupils to bring out these points and many others.

Safety, too, should be emphasized—how and when to cross streets and how to recognize and avoid poisonous plants.

In many grades, particularly those in the early elementary school, the results of these discussions should be written on the board and read by the children.

If the object of the trip is to collect seeds, leaves, rocks or any specimens, suitable containers should be carried. Each child should take a small notebook or some paper and a pencil and any other article needed, such as a pocket knife.

The follow-up work after a field trip is of great importance. It should stimulate the pupils to worthwhile discussions, to interesting art work, and to extended research in their school library. Often they cannot find the answers to their questions in their own libraries, and then a visit to the high school or public library, with the teacher or librarians helping them, will widen their horizons. Sometimes college librarians or professors can and will give valuable assistance. In the teaching of science, teachers as well as children should know and utilize all available

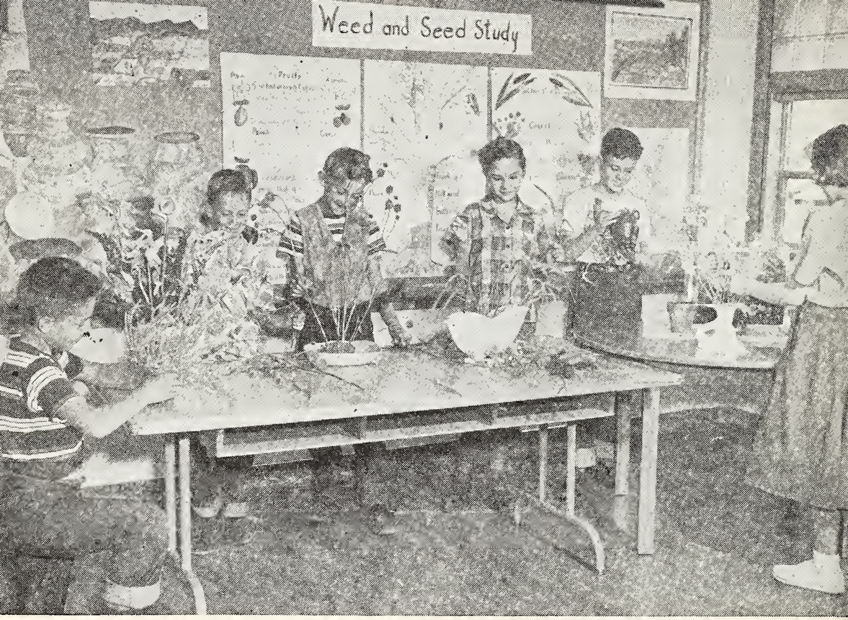
resources, including human resources. It bears repeating that the average teacher is unaware of the sources for science teachings that can be found near the school. Before school starts, every teacher would profit by exploring the neighborhood of her school.

Some of the field trips that may be taken for purposes related specifically to natural science are:

1. To collect seeds
2. To study trees and collect leaves for identification
3. To collect rocks
4. To see examples of erosion
5. To study birds
6. To study flowers
7. To see animals or garden products on experiment farms or other farms
8. To see animals in stock yards
9. To see chickens in a hatchery or a chicken yard
10. To see gardens (spring)
11. To notice signs of seasons (spring, winter and fall)
12. To observe stars from an observatory.

During the first week of school, a child brought a milkweed seed into a third grade. From a discussion of this and other seeds that were subsequently brought in, the children became so much interested that they found books in the library telling about the different ways seeds travel. They started a collection of seeds. With each specimen they wrote a statement telling the name, a description of the plant and how the seed traveled. When the pupils expressed the desire to see different types of seeds the teacher decided with them to take a field trip. During a survey of the neighborhood, she found an open field six blocks from the school. She made the trip there with another teacher and found a wide variety of plants and seeds.

The next day she told the class of her discovery and they made their plans. First they wrote to the owner of the field, asking if they might have permission to visit it. Then they discussed their purposes. They were looking for different types of seeds; they wanted to see the plants growing; they were interested in the



Jordan School District, Sandy, Utah

After the field trip, comes the process of sorting and classifying the collection if one has been made.

seed pods and the kinds of soil the plants needed. They decided they would collect only what they needed for study. They thought it would be better if they walked along the streets either singly or in twos as that would make it easier for people they passed. They agreed that they must not become too widely separated. They made a reading chart of their plans. Each child planned to take a box to hold the seeds, a pencil and small notebook or a few pieces of paper in case he wished to make notes on what he saw. Some of the boys had pocket knives which they thought they might need. All of the suggestions were put on a chart in order that the children might remember them.

The mother of one of the boys who lived near the field asked the class to stop by on their way back to see her garden and have light refreshments. This necessitated a letter of acceptance and further plans on how to act at a garden party.

When the class returned from the trip, each child showed his seeds to the others.

A chart made soon after the class started the collection was as follows:

How Seeds Are Spread

1. By the wind
    a. seeds with wings
    b. seeds with parachutes
    c. tumbleweeds

2. Plants that spread their own seeds
    a. plants with pods
    b. plants that pop open

3. By animals
    a. seeds with hooks
    b. nuts carried by squirrels.

As the children looked at each seed, they tried to determine how it traveled and what were the characteristics of the plant and flower. A few were well known to the children. The ones who had similar seeds worked together, examining the science books to learn more about their specimens.

Teachers should compile a list of science sources in their community and make this list available to any teacher who plans to take trips in connection with experiences in science.

Many cities or towns will have some of the following sources:

1. Airport
    a. weather, rainfall
    b. types of airplanes

2. Board of Health
    a. X ray machines
    b. vaccination

3. Cannery

4. Dairy
    a. pasteurization of milk
    b. refrigeration
    c. sterilization

5. Fire Station
    a. machine
    b. chemical for extinguishing fire
    c. water pressure
6. Food Storage—cold storage lockers
7. Green House
    a. soils
    b. care of plants
    c. variety of plants
8. Ice Plant
9. Lumber Yard
10. Music Store
11. Newspaper Office
12. Observatory (at university)
    a. study of planets
    b. distance and colors of stars
    c. moon
13. Ponds (near city)
14. Radio Station
15. Rock Quarry
16. Seed Stores
17. Telephone Office
18. University Museum
    Department of Geology

Auditory Equipment

Radio, recorders, and play-backs are not particularly useful in science teaching in the school except in the study of scientific principles basic to their development. There is a dearth of good

radio programs in science for elementary-school children. Recorder and play-backs have very restricted uses in the teaching of science. One particularly interesting recording for nature study is that made by the Laboratory of Ornithology at Cornell University. Tape recordings of talks on conservation by experts are also available.

Using Films

This is a medium that elementary teachers must use with some care. Most of the films produced are for high school use, but in the field of science there are a number of titles available for the elementary teacher. These should be previewed to see that they fulfill the purpose for which you plan to use them, that they are authentic and free from error, that the vocabulary will be meaningful to the child, and otherwise desirable. There are often great differences in the technical production quality of films. The use of films usually involves a greater expenditure than the use of other instructional materials.

These advantages may come from using sound films:

1. Action is well portrayed.
2. Sound production is very realistic.
3. Slow motion permits detailed study of fast action.
4. Time-lapse photography condenses action which normally takes a great amount of time.
5. Areas normally inaccessible for the children may be brought into the classroom.
6. Microphotography reveals action of minute organisms.
7. Miniature photography portrays in reduced form objects normally too large for study.

Most state universities and state departments of education are good sources of information about the source and availability of films. Many state universities maintain an extensive rental library. Of course, you will wish to consult the audio-visual director if your school is fortunate enough to have the services of such a person.

Other sources of film information (not exhaustive) are listed for your convenience.

1. *Consolidated List of Free Films*, De Vry Corporation, 1111 Armitage Avenue, Chicago, Illinois

2. *The Educational Film Guide*, The H. W. Wilson Company, 950 University Avenue, New York 52, New York

3. *Educators Guide to Free Films*, Educators Progress Service, Randolph, Wisconsin

4. *One Thousand and One, The Blue Book of Non-Theatrical Films*, The Educational Screen, Inc., 64 E. Lake Street, Chicago 1, Illinois

5. *United States Government Motion Pictures and Filmstrips*, Castle Films, 445 Park Avenue, New York 29, New York

Excellent sources of film prints are the following publishers:

1. Coronet Instructional Films, 65 E. South Water Street, Chicago 1, Illinois

2. Encyclopedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Illinois.

3. Teaching Films, Inc., 2 West 20th Street, New York, New York

4. Young America Films, Inc., 18 E. 41st Street, New York 17, New York

Mallinson has written a very helpful booklet, *The Use of Films in Elementary Science*.[1] He gives general suggestions about the use of films and also makes specific recommendations of titles. The arrangement of his bibliography of films is one that may well be adapted by local school systems as they make records of the use of films. It may be keyed to the local science-curriculum guide.

The following annotation includes the category of science topics for which the film was recommended, the title of the film, whether best suited for the primary (P) and / or intermediate (I) levels of the elementary school, whether a sound (Sd) or silent (Si) film, the number of minutes required for presentation, a series of code letters designating the film publisher (ex., COR), and a brief statement of the content of the film. If the film is colored, the letters, "cld" follow the type of film.

[1] Mallinson, George G., *The Use of Films in Elementary Science*, Faculty Contributions, Series 11, No. 2, June 1950. Graduate Division, Western Michigan College of Education, Kalamazoo, Michigan. pp. 23.

Air

*Air in Action I—Sd (cld) 10 COR

Demonstrates the science of aerodynamics by explaining simple parlor tricks in terms of scientific principles. Animated drawings are used to explain the principles and applications of air in action.

*The description of the film is read thus: The film, Air in Action, was judged to be of value for developing the topic, "Air." The film has a sound track, is colored, has a running time of 10 minutes, and is published by Coronet International Films (COR). It is of value for the intermediate level.

The booklet contains a long list of films annotated and cataloged in the same way. Appended to the bulletin are the addresses of the various publishers together with their designated code letters. Teachers in a particular school or community may wish to cooperate in building their own annotated reference list as they preview and use films.

Excellent films are included in the supervisor's bulletin which is adapted for reproduction here. This bulletin shows how supervisors may render an important service to teachers.

Films for Elementary Science

The films on the following list have been evaluated and approved for use by groups of teachers in one school system. Those marked (*) have been rated excellent for use in elementary science. Other films that are not included on this list would be given high rating in other systems where different teaching purposes were used for criteria.

All the films are 16 MM sound films. Most are one reel (10 minutes) subjects. Excepting in two or three instances where color was felt to be essential, they are in black and white. For additional information concerning these films, consult "Educational Film Guide", H. W. Wilson Company, 950 University Avenue, New York 52, New York, or the catalogs of various companies.

Jeff West
Coordinator of Audio-Visual Education
and Supervisor of Elementary Science
Stockton Unified School District
Stockton, California

Produced by	*Title* (Grade levels given are suggestive only)	*Grade Level*
Arthur Barr 1265 Bresee Avenue Pasadena 7, California	*The Red Hen (color)	K-3
Churchill-Wexler Film Prod. 137 North La Brea Avenue Los Angeles 36, California	*Wonders in a Country Stream	4-6
	*Wonder in Your Own Backyard (color)	1-6
Coronet Coronet Building Chicago 1, Illinois	*Magnetism	4-9
	*Science and Superstition	4-9
	*What Is Science	4-9
	*Life in a Pond	4-10
Encyclopedia Britannica Films 1150 Wilmette Avenue Wilmette, Illinois	*Fire	4-9
	*Water Cycle	5-12
Films, Inc. 330 West 42nd Street New York 18, New York	*What Is Soil	4-9
United World Films 1445 Park Avenue New York 29, New York	*Day and Night	6-12
Young America Films, Inc. 18 East 41st Street New York 17, New York	*Air All Around Us	4-8
	*Airplanes and How They Fly	6-10
	*Life in an Aquarium	1-10
	*Magnets	4-8
	*Solids, Liquids and Gases	5-10
	*This Is the Moon	5-10
	*The Sun's Family	5-10
	*Thunder and Lightning	4-9
	*Water Works for Us	5-10
	*What Makes a Desert	5-12
	*What Makes Rain	3-9
	*The Wonder of Chemistry	5-10

* Only the films marked excellent were selected from the longer list for inclusion here.

Filmstrips

Filmstrips are also called stripfilms and slide films. The filmstrip is a short strip of film consisting of a number of frames having some continuity to be projected. These instructional aids are very flexible in use and relatively inexpensive. Sound filmstrips are available which use a synchronized record with the film.

The Row Peterson Company, 1911 Ridge Avenue, Evanston, Illinois, has produced a series of "text films" in science. This medium is particularly valuable in the teaching of science because of the demonstrations which are possible. Examples of everyday happenings help clarify scientific facts. Some of the current titles are "Air About Us," "Simple Machines," "Living Things," and "Electricity." The L. W. Singer Co. also publishes nineteen filmstrips to supplement the teaching of elementary science. The Jam Handy Organization, 2821 E. Grand Blvd., Detroit 11, Michigan, is the most prolific publisher of this kind of material. The quality of the work is excellent. They have five series of filmstrips dealing with science: Health Adventures, The Sky Series, Our Earth Series, Water Life Series, and Basic Bird Study. The company provides a chart showing the correlations of their science filmstrips with the principal science textbooks in the field. This is a free and valuable service for the teacher. Other publishers of these materials are listed in the reference sources mentioned earlier in the chapter.

Filmstrips are economical and present no storage problem. They are easy to use and are particularly adaptable to situations where prolonged study and discussion is desirable.

Slides

Slides are easily made by teachers and pupils. The materials are inexpensive. Children may easily construct slides by tracing or freehand drawing with water colors, colored pencil, plain pencil, or colored ink on a piece of etched or roughened glass. Mistakes may be erased with ordinary eraser. If the picture is not to be used again, the slide may be washed clean with a detergent and used again. Mounting is necessary if one wishes to preserve a picture.

A picture cut-out or the frame from which it is cut may be mounted between two pieces of glass to make a silhouette slide.

A typed cellophane slide is made by folding a piece of carbon paper so the two carboned sides are separated by a piece of cellophane paper and typing thereon. Remove the cellophane and mount between cover glasses.

The most popular 2 by 2 slide is the photographic slide. It is constructed by printing a roll of 35 MM film and mounting the finished print between two cover glasses.

Directions for making these and other audio-visual aids are readily accessible in any book on this subject such as Kinder, James S., *Audio-Visual Materials and Techniques*, published by the American Book Company.

Alert teachers, who are proficient with a camera, may record their school science journeys permanently on the 2-by 2-inch photographic slide.

Objects, Specimens, and Models

The inexpensive, effective teaching materials are often referred to as three dimensional materials. Sources of these materials are many and varied. They can be borrowed from private collections, brought in from outdoors, purchased from local stores and supply houses, brought from home or constructed by the teacher and pupils in the classroom. Umbrella and tin can planetariums, dioramas, and atomic and molecular models are easily made and very useful in the classroom.

Collections, of which children are very fond, are a valuable source of objects, specimens, and models. Rock collections, model airplanes, souvenirs from vacation trips, pets, stuffed birds, fossils, insects, birds, and animals can be effective teaching materials.

Most of the collections which are commercially prepared are too finished and get only cursory glances. If children themselves assemble the items, arrange them and label them carefully, visitors to the school are almost dragged to look at them and to hear about them. A huge and valuable collection of rocks and minerals occupied a prominent place in the front hall of an elementary school. It had been presented to the school by a man

who had spent much money upon it. It remained practically unnoticed. A collection of stones from the school grounds was proudly displayed to any visitor to the class who made it. The experience is too common to be passed over as insignificant. Most people and all children like to be active and to have a part in what is being done.

Models, dioramas, charts, and pictures which children themselves have made—and they can make many to illustrate what they are doing—are far more meaningful to them than elaborate ones which can be purchased or borrowed. This has all been said before, but it is of such importance that it deserves frequent repetition.

A planetarium is a machine for showing the positions and movements of stars, planets, and moons in the sky. Pictures are thrown by the planetarium onto a large dome which seems to be the sky. It is usually considered a complex machine, but children can easily make a working model from an old umbrella without a handle, a small globe, paper, and glue. Stick paper circles of various sizes to the umbrella cloth to represent the stars of constellations. The North Star should be located where the rod is fastened to the cloth. The small globe is placed where the handle would be. By turning the umbrella you will be able to show how the northern sky constellations turn about the North Star. Children may also easily construct water cycle charts or make Holland tunnels and many other instructional aids.

Flat Pictures

Planned use of flat pictures can help teachers to do a better job of teaching children. Their popularity is widespread. They are inexpensive and can be projected by an opaque projector.

Experts say the pictures should be true reproductions, artistically attractive, give an accurate idea of relative size, and be free from excess detail but with a sufficient amount of detail for clarity.

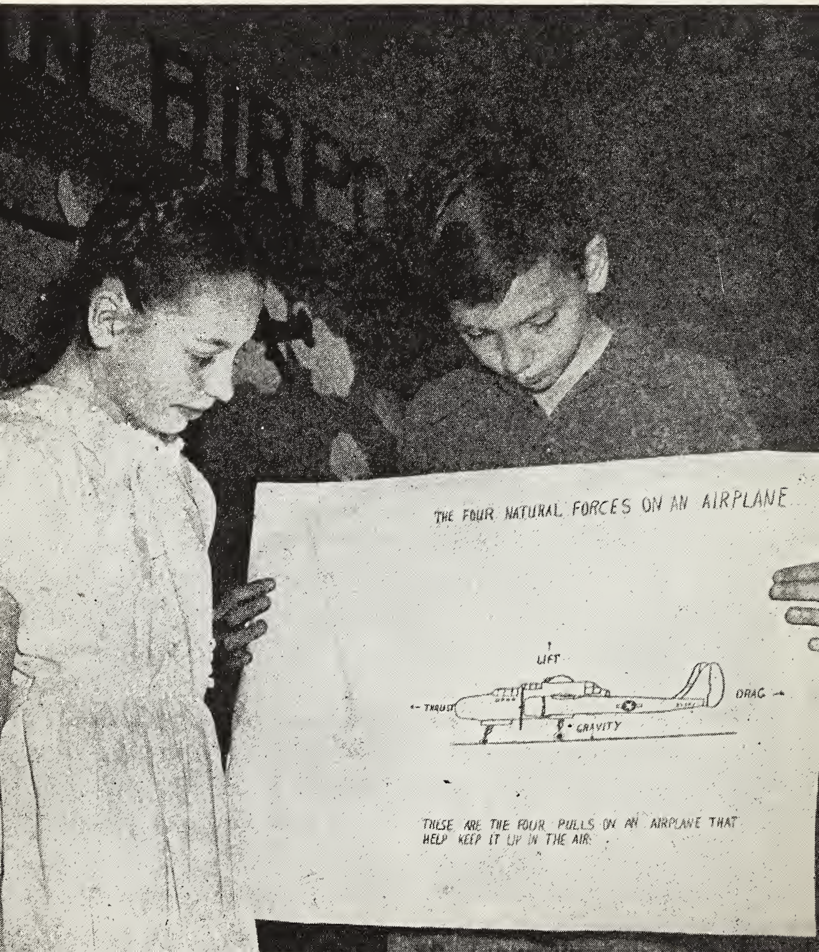
Teachers should mount these pictures on durable mountings and file them for future use. Excellent sources for these pictures are *Holiday*, *Life*, *Asia*, *Arizona Highways*, *National Geographic* and *Nature* magazines.

Graphic Materials

Included in this classification are such things as charts, maps, posters, cartoons, diagrams and drawings. These materials are usually made available to the pupils via textbook illustrations, chalkboards, bulletin boards, various forms of duplication on paper, and free educational and advertising material distributed by commercial firms.

At times, a homemade chart is more effective, to the viewer as well as to the child who made it, than a commercially prepared chart.

Denver Public Schools



Where to Start

Many teachers say, "I'd like to have an audio-visual aids program but we don't have any money." So much can be done with free and inexpensive materials and with pupil-made aids that this can scarcely be accepted as a good reason. Field trips, collections, and flat pictures cost nothing and are most usable in improving instruction.

It is common knowledge that the teacher who demonstrates ingenuity and resourcefulness with available materials soon finds greater financial support forthcoming from the administration.

Increase Your Understanding

1. Why is it true that a little doing is worth a heap of hearing?

2. Choose some topic in which children might become interested and that is significant to a program of science in the elementary school. Find out what films, filmstrips, slides and other visual aids can be bought to add meaning to the topic. Suggest aids that the children themselves could make.

3. Write a paper on the Effective Use of the Bulletin Board in Teaching Science. Be concise, but make your statement inclusive of all values that derive from an effective use of bulletin boards.

4. Make a collection of pictures that you can find in magazines to illustrate some topic in science, such as radar, vitamins, basic foods and pets. Would it be more educative to children if they found the illustrations and brought them to school? Why?

5. A film is available for showing in the school. Who should see it? Why? You will discuss various kinds of films, of course, if you wish to get the full value from this exercise.

Additional Readings

Blough, Glenn O. and Huggett, Albert J., *Elementary-School Science and How to Teach It*, The Dryden Press, 1951. pp. 30–42.

Dale, Edgar, *Audio-Visual Aids in Teaching*, The Dryden Press, New York, 1946.

Kinder, James S., *Audio-Visual Materials and Techniques*, American Book Company, New York, 1950.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 101–105.

Chapter 11

Evaluating the Worth of the Science Program

EVALUATION is the appraisal of the effectiveness of educative experiences in attaining predetermined purposes. It involves judgment. The evaluation of any program of instruction draws its most conclusive evidence from the later performance of the individuals who have participated. The experiences of other people in the field of science have indicated clearly that there are certain kinds of science experiences that are profitable only in most limited ways. It is highly probable that any science program which is being evaluated will be underway. It will be necessary for one to take a look at the experiences provided and reach some tentative decision about them before the actual effect on the pupils in this particular situation is determined. The effect of some experiences, on the other hand, can be so well predicted that one would stop them immediately to avoid the anticipated effect on the pupils.

Simply because a major emphasis will be directed to the ultimate effect on pupils, it does not mean that pupils must be subjected to trial-and-error programs which disregard the findings of the experiences of others. In short, there is need not only to appraise pupils' growth, but also to find out as much as possible about good science programs everywhere and eliminate those experiences which have been found to be definitely harmful, or at least unprofitable, so that the best assurance of optimum growth on the part of pupils will be secured.

There are certain circumstances and situations in the general school environment which give evidence of the worth of the science program. Inherent in the physical setting of the classroom, in the training and activities of the teachers, in the type of instructional materials to be used, and in the varieties of ways in which children respond, reside worthwhile information in science and significant learnings in skills and procedures that the evaluator cannot safely ignore. It is the intent of the discussion in this chapter to consider these more obvious and superficial evidences, as well as the basic one of pupil growth through science.

Is It a Planned Program?

One of the first questions that one should ask in evaluating a science program is: "Is it a planned program? Have adequate curriculum guides been prepared which will serve to enrich the study of science and to aid the teacher for instruction?" One of the major trends in science programs today is the development of curriculum guides by state, city, and county units, designed to insure a sequence of subject matter from grade to grade through the elementary school. Administrators and teachers and pupils and the community laymen have worked together in planning and carrying out a program of science instruction. There is no place for an impromptu, improvised program of science as a basic program in the elementary school.

Lee and Lee say, "For most schools and most teachers, it is felt that a science unit should be in progress, as well as a social-studies unit."[1] This statement is quoted to indicate that science should be an integral part of all elementary-school programs, not to advocate the particular organization mentioned in the quotation, although it has considerable merit for certain types of teachers. Many authorities feel that it is the unusual teacher who has the competence to integrate all experiences around a central unit, however desirable that may be. Another authority supporting the point of view that science programs should be well-planned, and well-planned for all children, has this to say:

[1] Lee, J. Murray and Lee, Dorris May, *The Child and His Curriculum*, Appleton-Century-Crofts Inc., New York, 1950. p. 501.

"For one thing, a suitable science-education program should be mandatory for all children. This assumes that science experiences will be designed more deliberately to strengthen the power of children to think critically and to act wisely; to substitute the rational inquiring of science for superstition and prejudice. The kindergarten, even the nursery school, is not too early a stage at which to begin using the methodology and content of science. Children learn that which they experience, and the world of the 4- or 5-year-old will make sense to him more quickly as astute nursery and kindergarten directors make increased use of living and growing things and of tools and materials in the young child's environment as a part of early childhood education."[2]

It is generally agreed that the teacher is the determining factor of the effectiveness of the science work in his or her classroom. It is also well known that curriculum guides are sometimes misused and that they are not necessarily an indication of what is actually happening in the classroom. In spite of these limitations, it seems wise to judge an elementary-school science program on the basis of the extent to which it is carefully planned for all children.

What Are the Basic Values?

"What values are basic to the planned science program?" is a very pertinent question at this point. Planning contributes to the effectiveness of a program. Whether or not it is a good program, as well as an effective one, depends upon the values on which it is based. If the basic value attached to the elementary-school science program is to teach diluted high-school or college-level content as preparatory to work at those levels, it will not even have approximated its maximum worth. The same is true if the value is one associated with unsound personification and sentimentality of nature study as expressed by such characters as Jack Frost and Mr. North-Wind. The most gross misuse of a science program, and one which produces the least value from a scientific point of view, is the one directed primarily to the development of reading skills through supplementary reading.

[2] Shane, Harold G. and McSwain, E. T., *Evaluation and The Elementary Curriculum*, Henry Holt and Co., 1951. p. 243.

This results in a verbal, abstract program of science, which makes no contribution to scientific method, to problem solving, or to the scientific attitudes.

A program of considerable value or worth may be built on the following purposes for a program of science teaching in the elementary school:

1. Developing in children scientific attitudes such as curiosity to seek answers to questions through firsthand observation and experimentation; open-mindedness which can be fostered through free discussion; and suspended judgment which waits for all evidence and checks and rechecks tentative hypotheses.
2. Enlarging upon the child's ever-present interest in the world about him and its influence upon him.
3. Giving the child a sense of security in his environment because he has made beginnings in understanding it.
4. Acquainting the child, on his level of growth, with the materials and information of science which he uses every day and which men have to use to make improvements in ways of living.
5. Supplying the child with a working knowledge of the generalizations that underlie the world of science, and which he can use in communication with others and in the solution of his own important problems.

Any elementary-science program not including these purposes as a part of its basic value pattern may be considered quite inadequate.

About the Teachers

What evidence of a good science program is found in the training, experience and attitude of the teachers? The amount of training that the teacher has had in science is not, in itself, especially important; but it points up the need for certain attitudes if the teacher is profitably to direct a science program. It is obvious, then, that as a part of the evaluation of the worth of the science program, one would want to make some survey of training and experience of the staff and of their background in the field of science. To the extent that such training does exist,

or there is a willingness to attain it, one may expect a more worthwhile program in science. The value of this training, of course, will depend upon its use in the direction of the purposes mentioned above.

The degree to which the teacher has shown some previous interest in the field of elementary science is evidenced by work that has been done with pupils. This is a good indication of the probable worth of a program in which the teacher may participate. The teacher's lack of scientific knowledge is not an insurmountable factor if in his or her attitudes there is expressed the willingness to be a participant in a learning group and to learn with the boys and girls. If one takes the attitude that he will help children find the answers to their questions, the children do not expect him to know all the answers. Consequently, he and they get more valuable experience in developing problem-solving techniques.

Is the teacher aware that nearly all children like science, and is he willing to build the instructional program around the expressed needs and interests of boys and girls in this area? The

The teacher who himself knows the facts of science and is aware of the pupils' interest can transmit his own enthusiasm.

Photo Lab, New York State University, Geneseo, New York

ability to recognize an interest in a science experience and the flexibility of operation and to include this experience as part of the on-going instruction of the classroom is an indication that the teacher may be doing a rather good job of directing the science program.

Another characteristic of teachers which is somewhat indicative of the worth of a science program is their willingness to participate in workshops designed for planning science programs or for the location of materials and equipment to use in the program or for improving the teacher's own background of science generalizations and information. A willing, intelligent teacher can overcome many lacks in previous training and at the same time be providing excellent instruction for pupils. If a good science program is to be found in the classroom of the school, it is desirable that the teacher encourage children to perform experiments themselves rather than use teacher-telling. A survey of the facilities in the classroom will readily reveal whether or not children have much opportunity to perform experiments for themselves. It is desirable for the teacher to surround children with scientific materials to intensify their curiosity about the world in which they live. A classroom devoid of living things, of tools and magnets, of inanimate objects such as rocks, nests, soil samples, and of many other scientific materials is good evidence that not much worthwhile activity is going on in the science program. A science program of considerable worth will be in evidence in the classroom in the following ways: There will be an informal atmosphere, with the teacher as a friendly director of activities. There will be provision for freedom of movement around the classroom so that the children may explore and work with materials in the science area or science corner. Science areas should include numerous materials to stimulate group and individual experimentation—magnets with different kinds of objects, magnifying glass, specimens of plants, and many other items that create opportunities for applying scientific facts. Growing plants of various kinds may be classified and properly marked. Adequate provisions will be available for keeping and caring for pets. Charts indicating observations and experiments will be included to increase the value of science

areas. Children will have the responsibility for the care of plants and animals and materials in the classrooms. The materials in the classroom will show evidence of balance among all the natural sciences, including physical, biological and chemical. There should be, on different levels of understanding and interest, an aquarium, a terrarium, and colorful bulletin boards creating interest in science. There should be evidence that the materials and exhibits involving science in the classroom are not static, but are constantly changing and growing.

Instructional Materials Used

What evidence of a good science program is found in the instructional materials used? It is trite to say that the currency of educational instruction in the schools throughout the country is the textbook. Although a few misguided individuals recommend the complete rejection of the textbook as an instructional medium, most authorities, aware of its merits, recommend that teachers be given careful instruction in the selection and use of textbooks so that these valuable materials may be used to the advantage of the school and the pupil alike. The proper use, then, of good elementary-school textbooks and supplemental books as instructional materials is evidence of a worthwhile science program.

What are the desirable characteristics of a good elementary-science textbook? It has been a matter of common knowledge since the early studies made in the '20's that the better the physical format of a book, the more it will be used. Its general attractiveness, its durability and usability are important but rather obvious, necessary attributes. Less obvious characteristics are these:

1. A good series of elementary-science textbooks will provide assistance for teachers which will allow them to conduct a flexible program and encourage them to exercise their own initiative. The assistance provided teachers should be of two types: They should be assisted in the choice of worthwhile science activities which are to be included because they can then become an integral part of problem solving in which the

children are engaged. They should have help in the preparation of materials and the direction of experiments which children must perform to solve their problems. In addition to these aids, it is safe to assume that the typical elementary teacher can profitably use some assistance with methodology, some help with the question of "how to teach" science.

2. A good series of elementary-science textbooks will place the setting of the science experiences, provided for children, in their natural environment so that the children will be aware that science is a part of their daily living, something that they can use and understand. In brief, the contents should be child-centered and environment-centered.

3. A good series of elementary-science textbooks will be so designed as to make children self-educative. This means that they will devote a large amount of effort to developing in children problem-solving techniques of the scientific method and scientific attitudes.

4. A good series will be readable.

Although science content should not be sacrificed, it is not intended that elementary-science textbooks should be only an encyclopedia of science information. The facts of science are so comprehensive it would be impossible for any one individual to retain a sufficient amount to attack all his problems. It is absolutely necessary, then, that he learn scientific ways of working and attacking his problems which will help him to collect and interpret the necessary data as he encounters his individual problems. The elementary-science program is apt to be of more worth if the supplemental books used in the science program are not preponderantly other series of science textbooks. These supplemental books may more profitably be books of identification, books of specialized information on particular subjects, books of experiments which children can perform, science biographies, and other trade books which include accurate science content.

The extent to which community, home, and school resources are a part of the instructional materials of the science program is a very good indication of its worth. The use of such resources

makes possible a program of doing, rather than one of reading and listening. It helps the children to understand that science is not strange and mystic, but something that is all around them and right at their finger-tips. This makes science real and understandable.

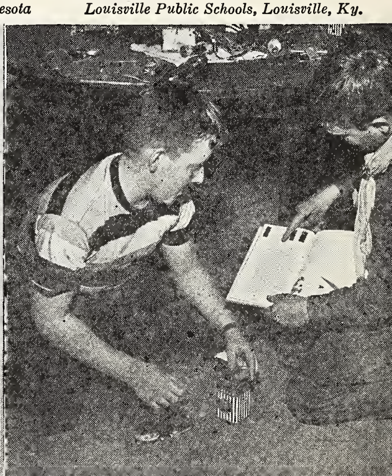
About Different Ways in Which Children Respond

In the general consideration of instructional materials, it should be ascertained whether they make possible every profitable approach to effective teaching. These approaches should include trips and observations, construction and drawing, reading, exhibits, notebooks, records, bulletin boards, school newspapers, discussions, assembly programs, using experts. Different children find that different media of learning are more profitable to them. The variety of approaches makes it possible for the teacher to have the desirable media available for each individual child, and after the confidence derived from the initial success in his particular medium, he can be taught that there are four or five or a half dozen other possible ways for him to learn. The child has one preferred medium for learning not only because of his out-of-school experience but also because he is generally exposed to only one profitable way of learning in the usual science program, and that is reading about or being told by an authority.

Each child has his own way of learning. Some work by themselves and some in groups; some read, some handle materials and some listen to oral explanations.

Bemidji State Teachers College, Bemidji, Minnesota

Louisville Public Schools, Louisville, Ky.



In evaluating the uses of various instructional media and different approaches to instruction, the teacher should expect increasing facility in such uses. Two examples will suffice to indicate increasing facility in the use of a vocabulary of science and the making of records.

If the program has been well planned, these words might be expected to be used by children with understanding in their discussion periods. Numbers in parentheses which follow each of the words indicate grade placement of the words as shown in Thorndike's *The Teachers Word Book*. A zero inside the parentheses indicates that the word either does not appear in the Thorndike list or has been given no grade placement in the elementary school.

First Year	*Second Year*	*Third Year*
animal (1)	balance (2)	apparatus (0)
baby (1)	electricity (0)	backbone (0)
boil (2)	evaporate (0)	change (1)
collection (3)	insect (3)	contract (3)
experiment (5)	machine (2)	expand (0)
magnet (0)	magnifying (5)	friction (0)
questions (1)	observe (2)	growth (3)
soil (1)	protect (2)	invention (3)
weather (1)	temperature (3)	lever (0)
wheel (1)	trip (1)	mammal (0)

Fourth Year	*Fifth Year*	*Sixth Year*
artificial (5)	amphibian (0)	adaptation (0)
astronomer (0)	atom (0)	conservation (0)
bacteria (0)	chlorophyll (0)	energy (4)
cell (3)	conductor (5)	extinct (0)
chemical (0)	dissolve (0)	hybrid (0)
geologist (0)	embryo (0)	microbe (0)
gravity (0)	fossil (0)	revolve (5)
pasteurized (0)	molecule (0)	species (0)
planet (0)	protozoa (0)	structure (0)
pollen (0)	vibration (0)	survive (5)

Although many of these words and others like them do not appear in the Thorndike list, they do belong to the vocabulary of science, and if many instructional materials and many approaches to instruction are used, they belong in the vocabulary of children.

Similar facility in making records and in using apparatus is in progress as these reports and charts show.

Primary Level:

Weather Charts

Blow, wind, blow.
This is a windy day.
Blow, wind, blow.

What Will a Magnet Pick Up?

Will a magnet pick up nails?
Will a magnet pick up other things?
Do you have a magnet?
You can find out what things a magnet will pick up.

Intermediate Level:

Notebook of Science

Cows are mammals. They eat green plants, hay which is dried grass, and many kinds of grain such as corn, wheat and oats. Juices in their stomachs change some of the food to milk. Milk is produced by glands in the body of the cow. Cow's milk is really for calves, but humans have found it to be an important food for them, too.

An Experiment

Problems: How do seeds sprout?

Materials: Lima beans, glass jar, sand, blotter, and water.

What we did: We opened the bean and saw the tiny plant inside. We lined the jar with a blotter. We placed sand in the center of the jar. We put some of the lima beans between the jar and the blotter. We poured water daily over the sand.

What happened: The roots broke out of the seeds. The stems began to grow up and the roots grew down. Leaves appeared and grew.

What we learned:

1. Inside each bean seed is a tiny plant called an embryo.
2. Food is stored in the bean seed to feed the embryo.
3. The tiny plant used the food until it could develop leaves and roots for manufacturing its own food.

Increasing facility in using words, apparatus and materials and in planning trips, making records if they seem appropriate and performing experiments should be evident in any classroom if the program in science is being effectively carried on.

About Pupil Growth

What evidence of a good science program is found in the growth of pupils through science experiences? Any real evaluation of pupil growth through science experiences will depend, as an initial step, upon the functional expression of the purposes of the work in terms of child behavior. A common purpose of elementary-science programs is "to help children be more scientific in their attitudes." Translated into a functional expression in child behavior, the objective may be like this:

1. To help children withhold decisions until they have evidence from all available sources
2. To help children learn the technique of finding answers for themselves
3. To help children learn to challenge and evaluate sources of information
4. To help children to be open-minded about truths and willing to change on the basis of further evidence.

The purposes as expressed in child behavior need not only be clear to the teacher, but it is also equally as essential that the purposes be clear to the pupils. Louis E. Rath makes this point quite vividly:

"If purposes are really made clear to the students, if I can help to clarify them, if students are almost continually thinking about them, then it is relatively simple for them and for me to recognize their progress in achieving them. Especially so when over and over again I say to them, 'How would you know that you are making progress along this line?' As they give more and more

examples of what progress would mean, these examples become landmarks or guideposts of successful efforts."

Continuing, Mr. Rath points out the advantage of conveying to the student your purposes as a teacher: "I try to do the same thing with respect to my own purposes as a teacher—I write them on the board, I try to clarify them, I try to give examples of achievement of those aims. As students see more clearly what my aims are, they are in a better position to judge them and to make progress in aims that I set for them, as well as in those goals that they have set for themselves. It is part of my job as a teacher to indicate these purposes of mine and to make them clear and to carry on some evaluation with respect to them. Values grow out of participation. Consequently, pupils need observation and practice in establishing values. Values are taught by example. Consequently, it behooves the teacher to set an example which is illustrative of best practices."[3]

The necessity of these purposes being stated in a functional manner may be further illustrated in this way. Children may be considering the problem of good nutrition in their elementary-science program. Unless they identify landmarks or guideposts of successful efforts in their study of nutrition, it will be difficult for them to evaluate their progress. What sort of landmarks should they have? Should it be a pencil-and-paper test of information on the seven basic foods and the amount of calories, or should it be the wise selection of the food consumed in their school lunch? In a certain midwestern city widely known as a medical research center, school people were sadly aware that the children in the school district, populated more largely than is the usual case by doctors, had the most knowledge of what constituted good nutrition, but were the most persistent consumers of "a coke and candy bar" for an adequate lunch. As in the choice of a balanced diet, so in the prevention of accidents, likewise, it is not enough to know statistics about the incidence of accidents. One must be found practicing safety and reducing the incidence of accidents in regard to his own personal behavior.

[3] Rath, Louis E., "Toward Better Evaluations," *Educational Leadership*, Vol. VIII, Association for Supervision and Curriculum Development, Washington, D. C. November, 1950. pp. 70–73.

One may be able to make a good talk about conservation, and in his activities throughout the rest of the day, give evidence by his destructiveness of an utter disregard for conservation of plants, animals and other resources in the community. A teacher may determine the extent to which a pupil is developing the scientific attitudes by careful observation and recording of that pupil's behavior. Most effective teachers feel today that one of the best ways of recording is the informal anecdotal record, which is flexible enough to meet the particular interests and needs of the individual teacher.

Anecdotal records usually include notes on all aspects of a total situation. Significant items in an anecdotal record that would show growth in the techniques and information of science and could be compared with earlier and later records in evaluating a child's progress in understanding science would be:

Does he use books to assemble information he wants? one book? many books?

Can he choose and correctly assemble and use appropriate apparatus for an experiment? Does he know the purpose for which pieces of apparatus serve? Can he name pieces of apparatus?

Is he able to identify plants, animals and non-living things and to relate them to himself, each other, and community life? useful and harmful plants and animals? safety devices? use and care of tools and machines? choice of food for a balanced diet? personal care?

Is he accumulating a store of generalizations which he can employ correctly in discussions?

Does he seem to be attaining scientific attitudes? suggest experiments to find out? help plan trips with definite aims which he states? show curiosity as evidenced by his questions? suggest need for more evidence? question the evidence?

This list is designedly left incomplete, for no anecdotal record can be planned in advance. General suggestions only should be made. Teachers grow in ability to include in their anecdotal records of individuals or a group those items in which they wish to evaluate progress along particular lines.

The extent of the development of scientific method and scientific attitudes could be determined by recording evidences of the

child's growth in problem solving, his originality and resourcefulness in finding answers, his suggestions made in planning experiments designed to solve specific problems, his willingness to change hypotheses in the face of new evidence. If the scientific method and scientific attitudes are really part of the child's behavior, this should be in evidence in other periods of the day which are not devoted exclusively to a consideration of science. For example, facility in recognizing and defining a problem is needed throughout the curriculum. It is applicable in all areas of the elementary school.

The individuality of this appraisal brings home with considerable force the necessity for a wide variety of experiences among the individuals, and for each individual in the class, in order that there may be ample situations wherein the teacher can have an opportunity to observe the child at work. The extent to which pupils have built up a background of generalizations and information and their ability to apply them in the solution of problems may be ascertained by simple pencil-and-paper tests or simple experiments. For example, pupils in the primary grades may be asked to put a little pan in the window and fill it with water. They will look at the water each day and write a story about what happens to it. After completion, the story may take a form similar to the following:

> **We took a pan.**
> **We poured water into the pan.**
> **We set the pan of water in the window.**
> **We watched it.**
> **One day the water was gone. It did not spill. It seemed to mix with the air.**
> **The water evaporated.**

After such an experience, children could be asked individually to try to describe some other situation in which water evaporated. They may also be asked such specific questions as: "When your mother hangs wet clothes on the line, what becomes of the water in them?" or, "After a shower, water sometimes stands in puddles on the ground and on sidewalks and pavements. Soon the water is gone. What happens to it?"

The following is a teacher-made test of the type which may occasionally be used with profit.

A TRUE-FALSE TEST ON MAGNETISM

Copy these sentences on a piece of paper. Place a "T" in front of the sentence if it is true. Place an "F" in front of the sentence if it is false.

1. Like poles of magnets attract each other.
2. A compass can be used to find directions.
3. A lodestone is not a magnet.
4. Lodestones are made by nature.
5. A magnet will pick up a silver dime.
6. Electromagnets are natural magnets.
7. Men have known about magnets for a long time.
8. Men knew about electromagnets before they knew about lodestones.
9. You can find out the north-seeking end of a magnet even if it is not marked.
10. The ends of a magnet are called its poles.

Questions for discussion such as the following may be used in connection with evaluating what has been learned about simple machines:

What are the uses of a screw?
When is a screwdriver used as a wedge?
When is it used as a wheel and an axle?
What does the work when you ride up to the second floor in an elevator?
What does the work when you walk up a stairway to the second floor?

The problem-solving ability of a student may be tested by an activity such as this after a study of current electricity:

Make up an experiment to show what happens to the compass when you change the direction of the current flowing through a wire. You have been told that the carbon rod in the center of a dry cell is the positive pole of the cell. You were told

that the current flows out of the cell from the positive pole. You were told that you could show what was happening in a wire that carries an electric current by laying the wire over a compass and passing a current through the wire. Something happened to the needle of the compass when you passed the current through the wire. You have one or two dry cells. You have plenty of insulated wire. You have an electric switch if you need one. You have a compass. Make up the experiment to show what happens to the compass when you change the direction of the current flowing through a wire over the compass. Write your record in a form similar to this form which is often used by scientists:

An Experiment

What I Wanted to Find Out
What I Needed to Use
What I Did
What I Found Out

These techniques of evaluation are not mutually exclusive. Observation which was mentioned earlier should continue throughout the use of the other techniques. For example, as a result of the experiment just tried, someone in the class may say, "We can't be sure with just one experiment. This should be tried under other conditions." One may insist that the results of the most recent experiment make their conclusions of last week all wrong. Both comments are conclusive evidence of scientific attitude.

Dramatic play may also be used profitably as an evaluative technique. A teacher in the Holcomb School at State University Teachers College, Geneseo, New York, used a Conservation Field-Day dramatic play experience in the classroom with a sand-table farm to give the class an opportunity to reveal the results of their work on conservation. One of the boys in the room was rather dull in a verbal way and had not previously made obvious contributions to the work, but he used his toy farm equipment to lay out a perfect farm in the sand table with appropriate contouring, drainage ditches, and cover crops. Had

this medium not been used, this boy would not have had an opportunity to reveal his accomplishments.

Another evaluative technique frequently used is to present pictures or descriptions of situations wherein something is in error. An adequate knowledge of the science generalization studied will make it possible for the pupil to identify the error. For example, one might present to a pupil a dry cell with a wire connecting both poles and spiraled about an iron core near the center of the length of wire, with a switch introduced into the circuit near the battery. The iron core forms an electromagnet when the switch is closed, allowing the current to flow through the wire. Show a picture in which the switch is open and the iron core is holding a number of nails. The child's ability to recognize this contradiction will be some evidence of his success with his work in magnetism and electricity.

Evaluation As a Process

A good program of evaluation should consist of at least four general procedures: 1. formulation of a clear statement of purposes in terms of child behaviors; 2. planning situations or recognizing existing ones where these behaviors may be expected to operate; 3. collection of evidence to show how and to what extent the purposes are being realized; 4. interpretation of the evidence in light of purposes to determine needs for modification and further development of the program.

The process of evaluation begins with findings about the pupils. The teacher should know the pupil's mental ability, achievement status in school subjects, emotional adjustment, experience background, and all other pertinent information. The evaluation of individualized instruction must itself be individualized. The individualization of evaluation begins with the study of the pupil and results in directional goals or purposes which the pupil can understand and accept as his own. These purposes will become a part of the broader instructional purposes of the particular school.

Parallel to the study of the child, the teacher must make a careful appraisal of the environmental setting. What are the possibilities and limitations in the resources of the teacher,

school, home and community? Programs will vary, depending on relative training of teachers, rural or urban communities, modern or traditional schools, and other cultural contrasts.

The most important final factor in evaluation is the process of exercising judgment to determine whether changes in the educational environment should be made to facilitate the attainment of purposes or whether some modification of purposes is necessary. Certainly, in regard to a purpose so widely accepted as that of developing scientific methods and attitudes among our pupils, there should be no modification of the purpose. If there is failure to attain that purpose, the educational environment should be modified and the experiences provided modified so that better results may follow. On the other hand, it is entirely possible that the number of generalizations and the amount of scientific information which were set forth as the original purpose for attainment by third-grade youngsters are entirely too difficult for children of that level of maturity. Under such conditions, it will be necessary that those who established the purpose modify it and expect accomplishments by pupils at a more appropriate level of maturity.

Common Weaknesses in Programs of Evaluation

One of the most common weaknesses of evaluative programs in elementary schools is the failure to appraise educational experiences in terms of predetermined purposes, for, too often, there is no expression of purpose on the part of the school staff, the teacher, or the pupils. Experiences are provided for the children on the basis of school and community tradition, the past experiences of the teacher, or because they are used in the adopted textbooks. Sometimes it seems that the attainment of knowledge is an end in itself. In some schools where planners have gone through the desirable step of writing down a statement of their purposes, they have not taken the next necessary one of making practical use of the statement.

Another weakness in programs of evaluation is to confuse measurement with evaluation. Measurement is an important part of evaluation, for it may be used to provide much objective information basic to judgmental decisions. It, however, only

Battle Creek Public Schools

By observing the boys out in the field, the teacher can evaluate their scientific attitudes and methods as well as any incidental science-facts they gain.

creates a potential of evaluation which materializes when the data are appraised in the light of the instructional purposes. Standardized tests and teacher-made tests of informational knowledge and generalizations should be used with an acute awareness of their specialized purpose and limited revelation. To indicate the quantitative status of a person's achievement fails to reveal anything about the desirability or value of the situation.

A final weakness in many programs of evaluation is the feeling that evaluation is something that comes at the end of a learning experience. Evaluation is a continuous experience, concurrent with and a part of good teaching.

Increase Your Understanding

1. Review the literature on tests and measurements for new techniques of measurement of understanding. *Science in General Education*, Progressive Education Association, Committee on the Function of Science in General Education of the Commission on Secondary-School Curriculum, D. Appleton-Century Company, New York, 1938, includes many sample tests of this type.

2. Describe the objectives of elementary-science instruction found in this chapter in terms of child behavior. Present this material in a two-column form, with the objective appearing in the first column and the child behavior, which would be evidence of the objective, appearing in the second column.

3. Prepare a rating sheet for evaluating different series of elementary-science textbooks. Use the rating sheet in comparing two of the most widely used series.

4. Explain what steps you think a supervisor might take in instituting an improved program of evaluation in an elementary school.

5. Defend the desirability of a teacher's using a check list to record the occurrence of evidences of scientific attitudes among her pupils.

6. Devise a procedure to evaluate growth in ability to perform experiments.

7. Visit a classroom or recall one in which you were a student. Evaluate it for its provisions to stimulate interest in science.

8. Devise a simple objective test to discover whether a child in the intermediate school seeks more than one source for evidence.

9. Suggest items in anecdotal records which would indicate that a child in primary school is growing in interest in science.

10. Review a book which has increased your interest in some aspect of science. Write your review, making your increased interest relate to the subject matter of the book. The book may be for adults or for children.

Additional Readings

Blough, Glenn O. and Huggett, Albert J., *Elementary-School Science and How to Teach It*, The Dryden Press, 1951. pp. 80–84.

Craig, Gerald S., *Science for the Elementary-School Teacher*, Ginn and Co., New York, 1947. pp. 27–36.

National Society for the Study of Education, 46th Yearbook, Part I, *Science Education in American Schools*, University of Chicago Press, Chicago, 1947. pp. 106–116.

INDEX

5
5
5